
Integrated Resource Plan

Appendix 2B

DSM/Load Forecast Integration

Load Forecasting and Demand Side Management Integration ↗



Load Forecasting And Demand Side Management Integration

August 29, 2011

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Executive Summary

BC Hydro currently uses coordinated but separate planning processes to develop a demand side management (DSM) plan and a before incremental DSM load forecast. The DSM plan load impacts are subtracted from the before incremental DSM load forecast to arrive at an after incremental DSM load forecast. Given these separate planning processes, BC Hydro has recognized that there is a need to ensure alignment between these two planning processes to minimize the risk of doubling counting or undercounting load.

A detailed review of this alignment across the residential, commercial distribution, commercial transmission, industrial distribution and industrial transmission sectors has been undertaken and is presented in this report. The report describes the load forecasting and DSM planning process for each sector, identifies and defines the key alignment issues, details the technical findings of the review and describes the resulting short and long term recommendations. An overview of the key findings and recommendations is provided below.

Historic DSM

The influence of historic DSM activities on the forecast has been identified as an area of concern. BC Hydro calibrates the before DSM load forecasting system to actual historic load, which has been influenced by past DSM activities. Therefore, there is a concern that the before DSM load forecast already incorporates the influence of historic levels of DSM and that subtracting additional DSM from this load forecast may result in the doubling counting of DSM load reducing impacts.

This review has shown that the BC Hydro load forecasting systems are sufficiently robust to account for the impacts of historic DSM activities and there is no significant concern that historic DSM activities are resulting in doubling counting effects in any of the sectors.

Codes and Standards

The area of codes and standards was also reviewed. Codes and standards are minimum end-use efficiency requirements that come into effect in a jurisdiction that are enabled by legislation or by regulation of manufacturers. U.S. based codes and standards are reflected in the average stock efficiency forecast of residential and commercial end uses of electricity produced by the U.S. Department of Energy's Energy Information Administration (EIA). This EIA forecast is one of the main drivers of the residential and commercial distribution end-use models that are used to produce the before DSM load forecast. BC Hydro's 20 year DSM plan also considers savings that can be achieved from BC and Canadian Federal codes and standards that target similar end uses as those represented in the EIA efficiency forecast data. As such, there is a potential for inconsistency in codes and standards planning assumptions between the before DSM load forecast and the DSM plan.

The review has shown that there are overlaps in codes and standards planning assumptions for some end uses between the DSM plan and the before DSM load forecast in the residential and commercial distribution sectors. These overlaps result in some double counting of load reductions associated with codes and standards.

It is recommended that in the short term, an adjustment to the load forecast be made to account for this double counting. This has been undertaken in the 2010 Load Forecast¹. In the long term, it is recommended that BC Hydro develop a common planning framework and stock turnover model that incorporates BC and Canadian codes and standards that are consistent between the two planning processes.

Natural Conservation and Natural Growth

The review addressed the areas of natural conservation and natural growth for the residential, commercial distribution voltage and industrial transmission sectors. The scope of the review did not include examining natural conservation or natural growth for the industrial distribution voltage sector given expected difficulties in explicitly identifying these elements of the industrial distribution load forecast, as a result of the method of forecasting applied to this sector. Natural conservation and natural growth account for energy reductions and increases that are associated with the natural course of events, uninfluenced by codes and standards, DSM programs or other factors. Material inconsistencies in natural conservation or natural growth could lead to under or over counting of load.

The review has found that both the DSM plan and the before DSM load forecasting processes recognize natural conservation and natural growth in the residential and commercial sectors, but that it is difficult to fully quantify the relative level of natural conservation included in each planning process in all of the sectors. The impacts of natural conservation and natural growth are embedded in aggregated planning assumptions for these sectors, which include combined impacts of natural conservation and natural growth, and other influences that cannot be isolated. For the industrial transmission sector the review found that there are different natural conservation assumptions applied in the DSM planning process and the before DSM load forecasting process.

It is recommended that in the short term, BC Hydro work towards better integration on this issue across all sectors and that in the long term, BC Hydro should develop a common planning framework and stock turnover model for residential and small commercial sectors. For the industrial transmission sector, BC Hydro should work to incorporate consistent natural conservation and natural growth assumptions in the DSM and before DSM load forecasting processes. For the industrial distribution sector, natural conservation and natural growth should be examined further in subsequent efforts involving alignment of Load Forecasting and DSM planning.

DSM Programs

The impacts of incremental DSM programs were also reviewed. Future DSM savings are forecast against baseline assumptions of expected future stock energy consumption and efficiency levels. If the baseline assumptions used in the load forecast are substantially different from the DSM plan baseline assumptions, there may be load double or under counting between the DSM plan and the load forecast.

¹ See Appendix 5 of the 2010 Load Forecast.

The review has found that there may be overlaps taking place but it has not been possible to quantify the impact. However, it is recommended that where information is available and changes are practical, adjustments be made to ensure load forecasting and DSM program planning processes use consistent planning assumptions regarding baseline efficiency levels and other planning assumptions that impact DSM program planning. In the long term, it is recommended that BC Hydro develop a common planning framework and stock turnover model for the residential and small commercial sectors. It is also recommended that staff who prepare the industrial and commercial transmission voltage load forecasts and DSM plans continue to meet annually to review the assumptions used for each account and sub-sector to ensure the potential for double or undercounting of DSM program impacts is minimized.

Other areas of load forecasting that were addressed in the review included basic stock turnover, price elasticity, conservation rates and the efficiency rebound effect. The review found no concerns in these areas across all sectors.

1.0 Introduction

BC Hydro prepares a 20-year electricity load forecast on an annual basis that is used as an input to many planning and regulatory processes. The development of the electricity load forecast is undertaken using established and sound practices in load forecasting. Load forecasting practices are adjusted over time to adapt to changing forecasting needs, information sources and best practice developments.

At this time in the electricity industry, demand side management (DSM) is being pursued in many jurisdictions as a cost effective resource to address demand-supply gaps. In British Columbia (B.C.), the *Clean Energy Act* requires BC Hydro to respond to the British Columbia energy objective to take demand-side measures and to conserve energy, including the objective of reducing its expected increase in demand for electricity by the year 2020 “by at least 66%”. The British Columbia Utilities Commission (BCUC) must consider and be guided by this same objective when it reviews BC Hydro’s DSM-related expenditure schedules under section 44.2 of the *Utilities Commission Act*. The BCUC must also consider and be guided by the extent to which BC Hydro’s DSM are cost-effective within the meaning of the Demand-Side Measures Regulation. The most recent BC Hydro long term resource plan incorporates DSM measures providing approximately 9,900 GWh per year of energy and 1,700 MW of capacity by F2021. This level of DSM represents 79 per cent of the load growth by F2021. This represents a substantial increase in the level of reliance on DSM compared to past resource plans. The F2002 DSM Plan targeted 3,600 GWh per year of savings by F2012.

BC Hydro currently uses coordinated but separate planning processes to develop a before incremental DSM load forecast and a DSM forecast. The DSM forecast is subtracted from the before incremental DSM load forecast to arrive at the after incremental DSM load forecast which is then entered into an optimization model which considers supply side resources to address the remaining demand-supply resource gap. Given these separate planning processes, BC Hydro has recognized that there is a need to ensure alignment between the before incremental DSM load forecast and the DSM Plan.

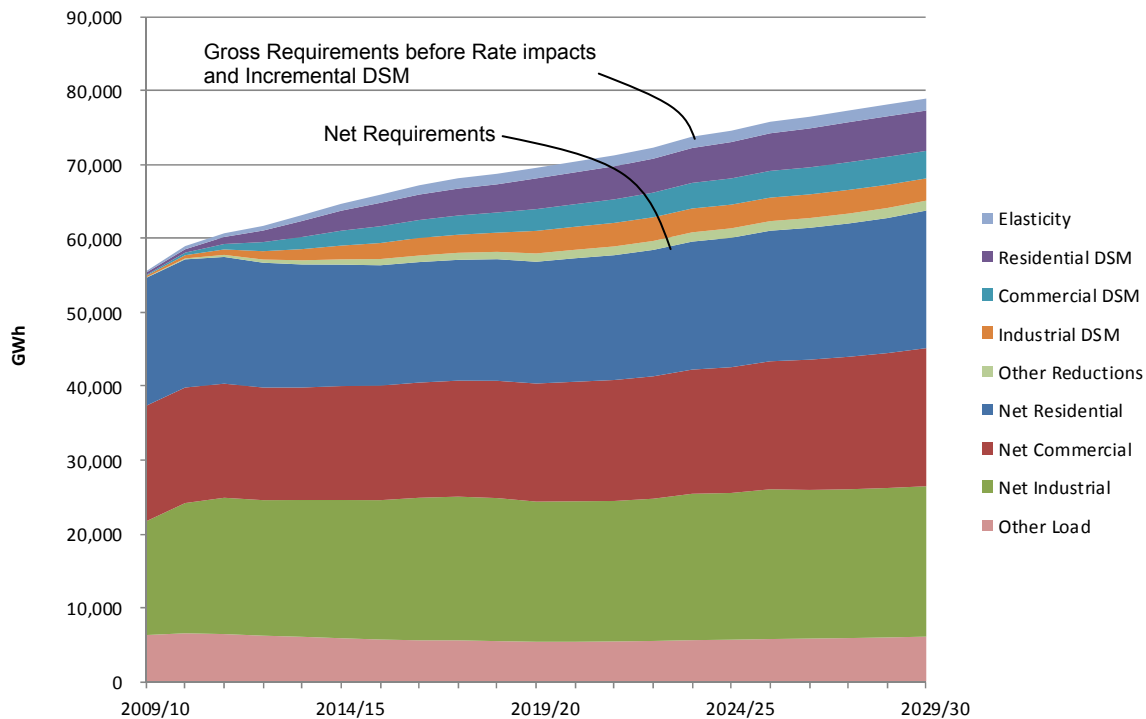
This report provides a review of the alignment between the DSM Plan and the before incremental DSM load forecast, addresses the significance of any potential overlaps, gaps or inconsistencies and provides a recommendation on how to proceed in the short term and the long term where there are issues identified. Also, this report addresses the issue of how estimates of historical DSM savings impact the load forecasting process and the load forecast projections. As well, this report addresses the area of natural growth in the load forecast. Many of the issues in this report are addressed in more detail in the residential section, as this is the first sector addressed. Subsequent sections refer to the residential section when there is duplication of issues across sectors, to reduce the duplication of issue discussion within the report. The commercial and industrial sections focus mostly on points that are specific to these sectors.

2.0 Background

2.1 Load Forecast Sectors

The BC Hydro load forecast is composed primarily of the residential, commercial and industrial sectors. Figure 1 shows the BC Hydro 2009 gross system load forecast showing how the gross system requirements before rate impacts are met through elasticity² and demand side management reductions to arrive at the net load forecast for residential, commercial, industrial and some other system load.

Figure 1 – BC Hydro 2009 Integration System Load Forecast



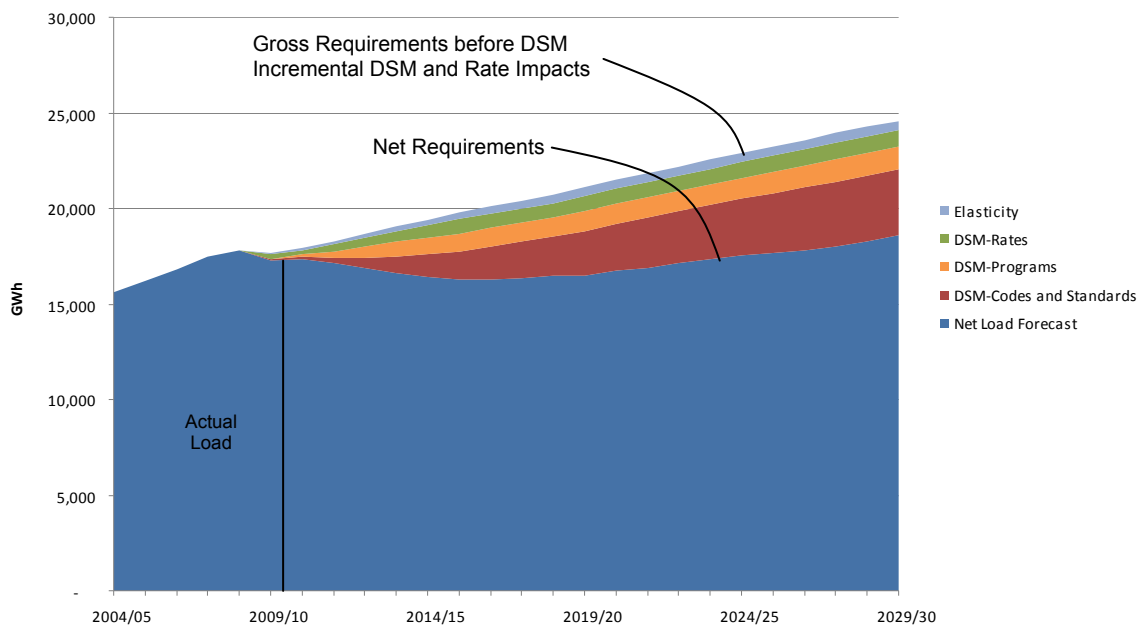
Further details on each of the main sectors are addressed below including a description of the forecasting methodology applied to each sector.

² Elasticity refers to estimates of reduction in load associated with future rate increases under flat design rate structures and a common elasticity assumption amongst the different rate classes. This is otherwise known as the rate impacts as contained in BC Hydro's Annual Load Forecast document.

2.1.1 Residential Sector Description and Load Forecasting Process

There are approximately 1.6 million residential sector accounts in the BC Hydro sales territory. Residential customers use electricity for a wide variety of purposes such as space heating, water heating, refrigeration and plug-in loads such as computers, TV, etc. Most of these end-uses have an expected rate of electricity consumption measures either as unit energy consumption (UEC) values (kWh/account/year) or efficiency factor (EF) values measured as output/input. The average number of each of the end-uses in each residential is referred to as the residential end-use saturation rate. The residential sector is forecast on a regional basis and also by dwelling type, e.g. single/duplex housing units, row houses, apartments and mobile and miscellaneous housing units. Figure 2 shows the 2009 residential system load forecast³.

Figure 2 – BC Hydro 2009 Residential Load Forecast



The residential before incremental DSM and rate impacts load forecast is developed using the residential statistically adjusted end-use (SAE) model. This is a model that combines traditional regression-based forecasting with detailed end-use data to produce a forecast of residential use per account.

Key inputs to estimating the residential use per account are unit energy consumption (UEC) and efficiency factor (EF) values for approximately 15 residential end uses and corresponding saturation rates of each end use. BC Hydro load forecasting relies upon the UEC and EF values produced by the Energy Information Administration (EIA) for the Pacific Region, where the Pacific region includes California, Oregon, Washington, Hawaii and Alaska. The saturation rates are derived from information provided by the BC Hydro Residential End Use Survey (REUS). The UEC input values are calibrated and adjusted to

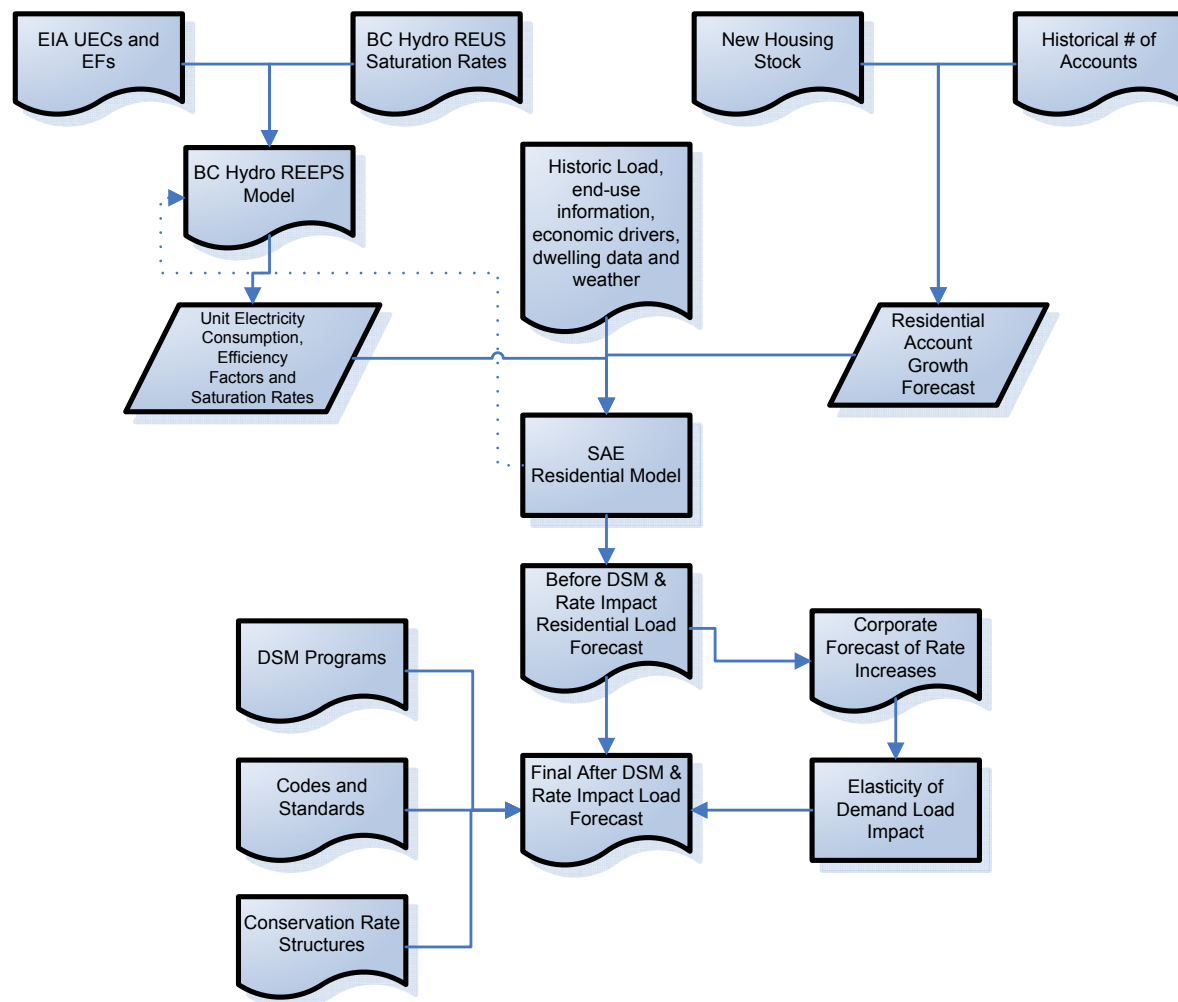
³ Figures that show gross requirements for each sector such as residential, commercial and industrial do not include distribution and transmission losses.

BC Hydro's residential use per account data in the Residential End Use Energy Planning System (REEPS), as originally developed by the Electric Power Research Institute.

A residential account growth forecast is developed by adding a forecast of new housing starts to the historical number of residential accounts. This forecast is prepared on a regional basis and by housing type where the Conference Board of Canada provides data. Multiplying the forecast of use rate per account by the account forecast creates the final residential load forecast before rate impacts and incremental DSM. A forecast of incremental residential DSM savings is then subtracted and adjustments are made for general rate elasticity of demand impacts to arrive at a final after rate impacts and incremental DSM residential load forecast.

Figure 3 provides an overview of the residential load forecasting process. Further details of the SAE model are contained in Appendix 1.

Figure 3 – Residential Load Forecasting Process

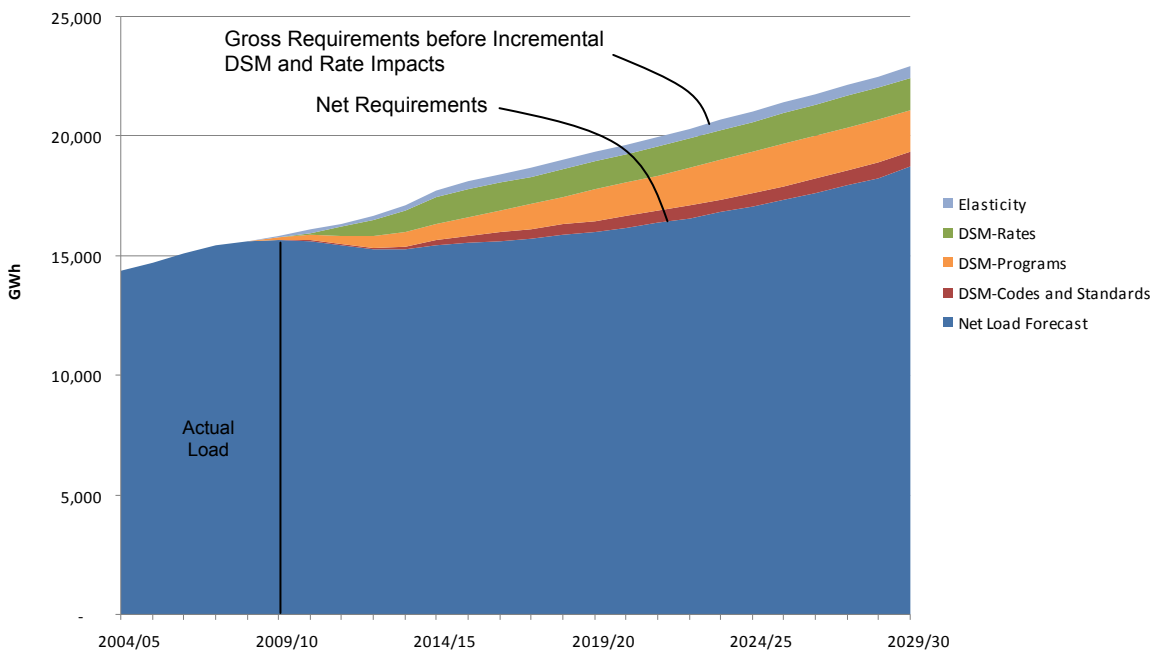


2.1.2 Commercial Sector Description and Load Forecasting Process

The commercial sector is composed of commercial distribution voltage and commercial transmission voltage customers as well as irrigation, street lighting and BC Hydro's own use. The commercial sector uses electricity for a range of services such as lighting, ventilation, heating, cooling, refrigeration and hot water.

Employment, retail sales and commercial output are the main economic drivers of the commercial distribution sales forecast. Forecasts for these drivers as well as forecasts of commercial distribution sector equipment efficiency and equipment saturation for heating, cooling and other commercial uses of electricity are combined in SAE models that forecast future sales. The commercial distribution sales forecast assumes normalized weather as with the residential sector. For commercial transmission accounts, the load forecast is developed on an account-by-account basis using historical intensity patterns, forecasts of production from third part consultants and information from BC Hydro key account managers.

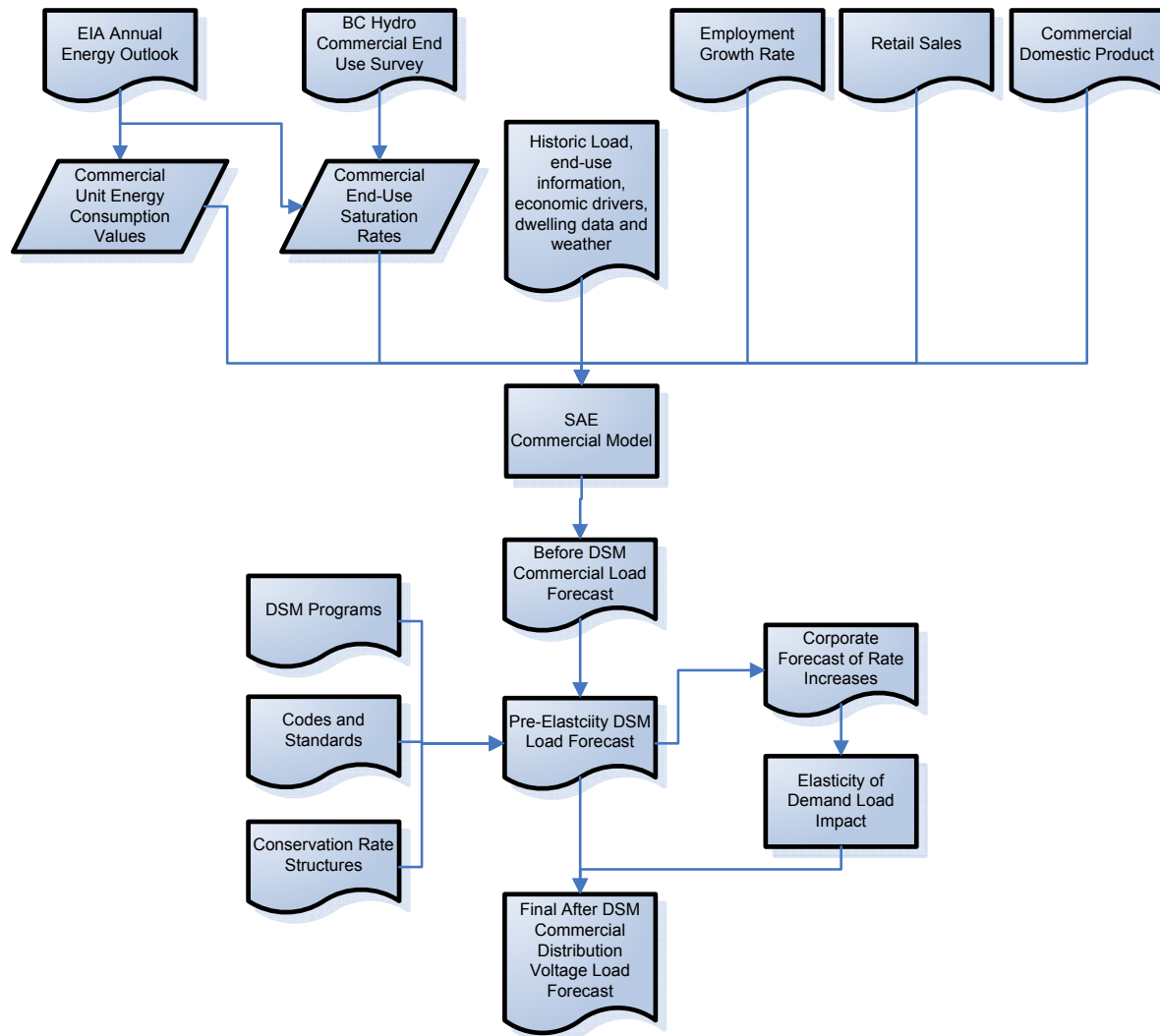
Figure 4 – Commercial 2009 Load Forecast



The load forecasting process for commercial distribution voltage customers follows a similar process as for residential customers. UEC and EF values from the EIA are used in the forecasting process. The BC Hydro Commercial End-Use Survey (CEUS) is used to develop saturation rates for each of approximately 10 commercial end-uses. Employment growth rates, retail sales and commercial domestic output forecasts, along with historical data, is entered into the SAE model to produce a before incremental DSM and rate impact load forecast. A forecast of incremental commercial DSM savings is then subtracted and adjustments are made for general rate elasticity of demand impacts to arrive at a final after rate impacts and incremental DSM commercial distribution voltage load forecast.

Figure 5 provides an overview of the commercial distribution voltage load forecasting process. Further details of the SAE model are contained in Appendix 1.

Figure 5 – BC Hydro Commercial Distribution Voltage Load Forecasting Process



2.1.3 Industrial Sector Description and Load Forecasting Process

The industrial sector load, which is BC Hydro's most volatile sector with respect to load variations, is 20 per cent small industrial distribution voltage load and 80 per cent large industrial transmission voltage load.

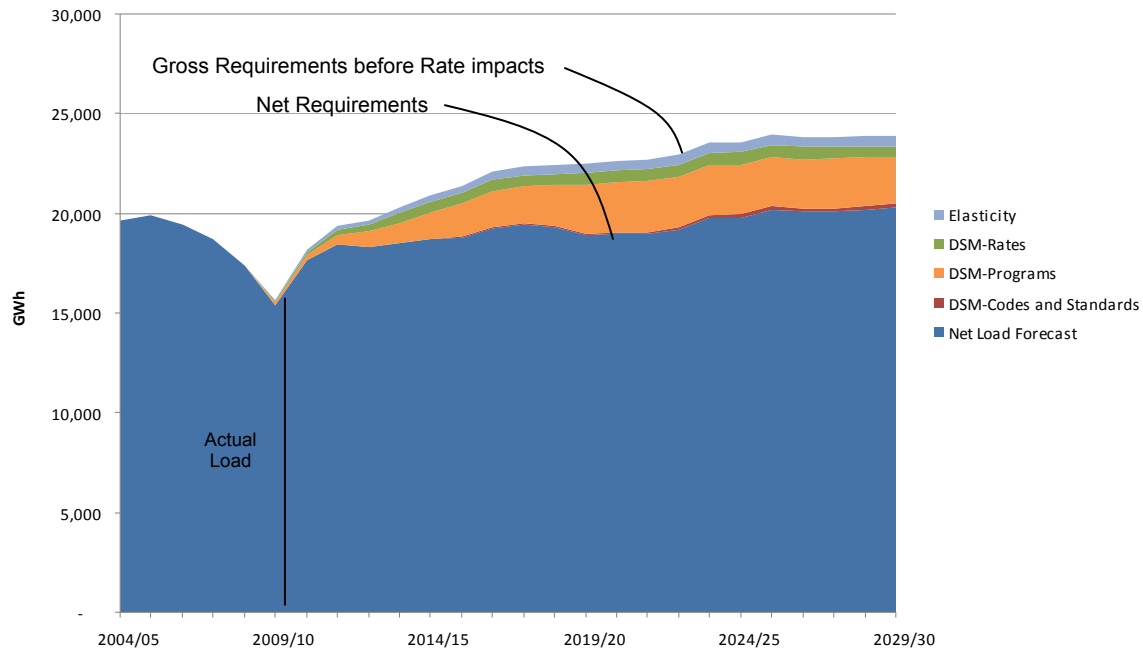
The 2009 industrial distribution voltage sector forecast is supported by a regression of consumption per unit of Gross Domestic Product (GDP) with calibration to actual data. There is no end-use data used in this process.

The industrial transmission voltage sector is forecast based on an account by account analysis using input from historical consumption levels, historic DSM levels, production and

intensity forecasts informed by BC Hydro key account personnel, external studies and external consultants.

The 2009 industrial load forecast is shown in Figure 6.

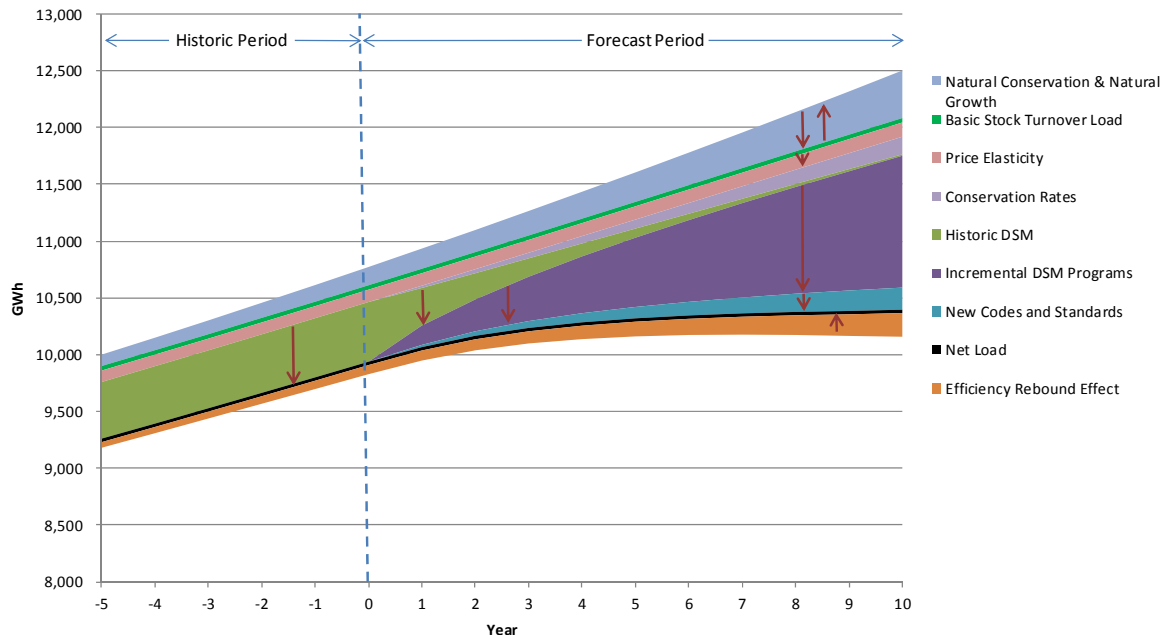
Figure 6 – 2009 Industrial Load Forecast



2.2 Components of the Load Forecast

The conceptual components of the load forecast that are addressed within this report are shown below in Figure 7 with an arrow showing the direction of the influence of the load component on overall load requirements. Figure 7 is for illustration purposes only and does not represent any specific forecast produced by BC Hydro.

Figure 7 – Generic Illustration of Load Components



Each of these load components is discussed below.

Natural Conservation – For the purpose of this review, natural conservation represents a reduction in load as a result of factors which take place without incentives or exogenous actions. Natural conservation includes load or efficiency changes that occur “naturally” and result from general technology improvement or from market take-up of more efficient end-uses as a result of currently enacted codes and standards. For example, more efficient light emitting diode (LED) televisions developed by industry use less electricity than older cathode ray televisions or even more recently introduced liquid crystal display (LCD) televisions. Natural conservation also includes permanent behavioural changes that may result in lower end-use intensity.

Natural Growth – This represents growth in load that occurs naturally, independent of exogenous efforts. Natural growth can be reflected in several ways including:

- 1) *New End Uses* – End-uses that do not exist today or which are not prominent in the market place, e.g. electric vehicles, home computers (in the past)
- 2) *Feature Creep* – New end-use features that do not exist today or which are not prominent in the market place, e.g. displays on refrigerator doors, 3-D televisions, etc.

- 3) New/Increased Size of Areas in Existing Stock – New areas to be heated, cooled and illuminated, e.g. home add-ons as a result of renovations

Basic Stock Turnover – This represents the load influenced by changes in end-use stock and usage levels (Intensity) as a result of growth in accounts, replacement of stock resulting from stock decay (before end-of life removal from the market) or from stock reaching end of life, as well as natural changes in efficiency and intensity resulting from natural conservation and natural growth.

Price Elasticity – This represents short-term and long-term load impacts that result from a change in overall real electricity price levels. This is what is referred to as the rate impacts in BC Hydro's Annual Load Forecast document.

Conservation Rates – This represents a change in load as the result of consumer behaviour resulting from rates structures that would enable conservation, such as a multi-tier rate structure.

Historic DSM – This refers to DSM that occurred in the past and which had an impact on load in the historic period. Historic DSM has a period of persistence that continues into the forecast period.

Incremental DSM Programs – Utility offered electricity conservation programs that encourage customers to implement more efficient end-uses and/or to undertake behavioural changes that result in electricity conservation. DSM programs can lead to reductions in load in the period in which the DSM program is subscribed to and can also have a persistent impact into the future. The duration of DSM persistence varies by DSM program; the savings attributed to the program reduce to zero electricity savings at some point in the future, but not necessarily within the planning horizon.

New Codes and Standards – New legislated or regulated end-use technology efficiency standards which are anticipated to take effect in the forecast period. Existing legislated or regulated end-use technology efficiency standards are previously embedded in new and replacement end-uses that influence natural conservation and baseline stock turnover.

Efficiency Rebound Effect – This represents an increase in load due to a higher take-up volume or increased usage of end-uses as a result of them becoming more efficient, e.g. using a higher volume of seasonal lights due to new lights being more efficient than older lights, or leaving the newer lights on for longer period of time. The efficiency rebound effect can take place through natural efficiency improvements or through DSM induced efficiency improvements. For the purposes of this report, efficiency rebound effects associated with DSM are considered to be included within the DSM impacts. The efficiency rebound in Figure 1 is associated with natural efficiency improvements.

3.0 Residential Sector

3.1 BC Hydro Residential DSM Plan

Three components to the residential DSM Plan are DSM programs, Rates Structures and Codes and Standards. These are described below. There are also supporting initiatives for the overall DSM Plan.

Residential DSM Programs – These are 10 incentive based programs aimed to achieve electricity savings in the residential sector. In addition, there are Sector Enabling Activities included in the DSM Plan. The DSM programs that operate in the residential sector are:

1. Behavioural;
2. Voltage Optimization;
3. Lighting;
4. Sustainable Community;
5. Refrigerator Buy-Back;
6. Renovation Rebate;
7. New Home;
8. Low Income;
9. Appliances And Electronics; and
10. Load Displacement.

Rate Structures – A two-step inclining block rate structure. The residential including block application was filed in February 2008 and was subsequently approved by the BCUC.

Codes and Standards – BC Hydro includes in the DSM Plan, all electricity efficiency achievement associated with all codes and standards impacts anticipated in British Columbia.

Overall DSM Plan supporting initiatives include:

11. Public Awareness and Education;
12. Codes and Standards Support;
13. Community Engagement;
14. Technology Innovation;
15. Indirect and Portfolio Enabling; and
16. Information Technology.

3.2 EIA Residential Forecast

The EIA forecast of efficiency of end uses, which is used as input to develop the load forecast before DSM and rate impacts, follows the following principles:

- No new regulations beyond those currently embodied in law or new government programs fostering efficiency improvement will take place over the forecast horizon;
- There will be no radical changes in technology or consumer behaviour over the forecast horizon;
- The residential sector UEC and EF values are calibrated to the actual stock, including efficiency levels, based on shipping data for the census region;
- Technologies which have not gained widespread acceptance today will generally not achieve significant penetration by 2030;
- Currently available technologies will evolve in both efficiency and cost. In general, technologies will be less expensive than those available today in real dollar terms;
- When replacing technologies, consumers will behave similarly to the way they behave now;
- Intensity of end-uses will change moderately in response to price changes;
- New end uses will continue to expand, but at a decreasing rate; and
- Only currently implemented tax credits for energy efficiency products and renewable energy generation apply over the forecast horizon.

Given the above assumptions and methodologies used to develop the forecast of efficiency, the EIA notes that their projections are not considered to be statements of what will happen but of what might happen, given these assumptions. The projections are business-as-usual trend estimates, given known technological and demographic trends.

The EIA forecast is influenced by many factors including:

- Base stock turnover rates with decay and replacement assumptions;
- Existing US Federal legislation and regulations including standards and legislated efficiency programs;
- Natural conservation assumptions, e.g. changes in efficiency that would result from natural processes such as market development, technology costs, technology efficiencies and consumer behaviour;
- Fuel switching;
- Distributed generation and customer based generation assumptions based on current costs and incentive programs;
- Short-term elasticity factors and electricity price increases; and

- Efficiency rebound, whereby improvements in efficiency lead to increased usage as a result of the cost savings associated with the improved efficiency.

3.3 Residential Sector Key Issues

This section addresses the key components of the residential load forecast and examines the alignment between the residential before incremental DSM and rate impacts load forecast and the residential savings forecast contained in the DSM Plan.

As shown in Figure 3, there are several inputs to the residential load forecasting process. Many of these inputs are based on data that is specific to British Columbia, with the main exception being the UEC and EF values that are developed by the EIA for the U.S. Pacific census region. When the current BC Hydro SAE load forecasting model was developed this data source was selected as the best source of representative forecast UEC and EF values, which could be expected in British Columbia.

To provide a framework to review the main areas where there might be overlaps or gaps with the load forecasting process and savings estimates in the DSM Plan, each of the components of the load forecast, as outlined in Section 2.2 are reviewed.

3.3.1 Natural Conservation

Natural conservation drives a reduction in load as a result of the natural take-up in the market place of more efficient end-use technology or as a result of permanent usage intensity changes. Replacement or new end-use technology can be more efficient as a result of existing codes and standards or through general technology advancement. Permanent usage intensity changes can result from permanent changes in consumer usage behaviour which occurs naturally.

What is important from a load forecasting and DSM integration perspective is whether both planning processes include natural conservation in their forecasting assumptions and assume a similar level of natural conservation.

Upon review of the planning processes, it has been found that both planning processes include acknowledgement of natural conservation. The DSM Plan incorporates natural conservation through the inclusion of free-riders in the DSM Plan forecasts and through the practice of limiting the persistence of DSM program savings. The load forecast incorporates natural conservation through the input received from the EIA and by calibrating the load forecast model to historic sales, which also includes natural conservation. The EIA includes natural conservation in the EIA stock turnover model through gathering input from technology experts that develop projected cost and performance characteristics for EIA whereby technology improvement are projected based on trends in standards, product enhancements and research and development. Also, the EIA includes a factor in the EIA stock turnover model that links the rate of technological advancement with the price of electricity and other fuels. High electricity prices lead to high rates of technological improvement being incorporated into the forecast, and vice versa.

In order to determine if the level of natural conservation is consistent between the two planning processes the natural conservation impact must be quantified. This can be ideally done by calculating the difference between the unit energy consumption of new technology devices in each year of the forecast and the unit energy consumption of existing technology devices and multiplying the differences by the volume of replacement and new devices in each corresponding year of the forecast. To separate natural conservation from other effects, the UEC of the new technology devices should only include the impacts of existing codes and standards, general technology changes and permanent intensity change and exclude the impacts of other load components discussed in Section 1.2. The difficulty in quantifying these impacts in both the DSM Plan and the Load Forecast is that these effects are embedded in planning assumptions that include other factors, making it difficult to separate out the natural conservation effect. Neither planning process specifically isolates information that will support the full quantification of natural conservation alone, although the DSM Plan does contain estimates of free ridership and persistence for each program.

The alternatives to move forward given the lack of full clarity on the issue of natural conservation are:

1. Continue planning using current processes.
2. Continue planning using current processes and work toward improved sharing of planning assumptions between the DSM planning and load forecasting groups to support better alignment on natural conservation where possible. Continue to pursue additional clarity on marginal efficiency values from the EIA which will support quantifying natural conservation in the Load Forecast.
3. In the long term, develop a common planning framework and stock turnover model for DSM planning and load forecasting that will allow for a consistent level of natural conservation to be included in the planning process.

Alternative 2 is the best short term solution but to fully address the issue of natural conservation, alternative 3 should be pursued.

3.3.2 Natural Growth

The main issues within the scope of this review in the area of natural growth is whether or not both the DSM and load forecasting processes incorporate natural growth in the respective forecasts and whether or not the levels of natural growth assumed in the processes are consistent.

For this review, natural growth is reviewed from the perspectives of miscellaneous end uses and significant new end uses.

Natural Growth – Miscellaneous End Uses

The EIA information that BC Hydro uses in the load forecast for UEC and EF values is based on a planning assumption that technologies, which have not gained widespread acceptance today, will generally not achieve significant penetration by 2030. However, the EIA does include growth in miscellaneous end-uses in their “miscellaneous” or “other” end-

use category. The EIA tracks trends in this category and incorporates the current trend factors in the development or projections.

Figure 8 shows the F2009 baseline index trends in residential end-use load growth based on the EIA US residential forecast. The legend is ordered from top to bottom to align with the lines in the graph based on the 2030 value. As shown, “other uses” has the highest growth rate over the forecast horizon. This is also shown in Figure 9.

Figure 8 – EIA US Residential Electricity Load Forecast by End-Use

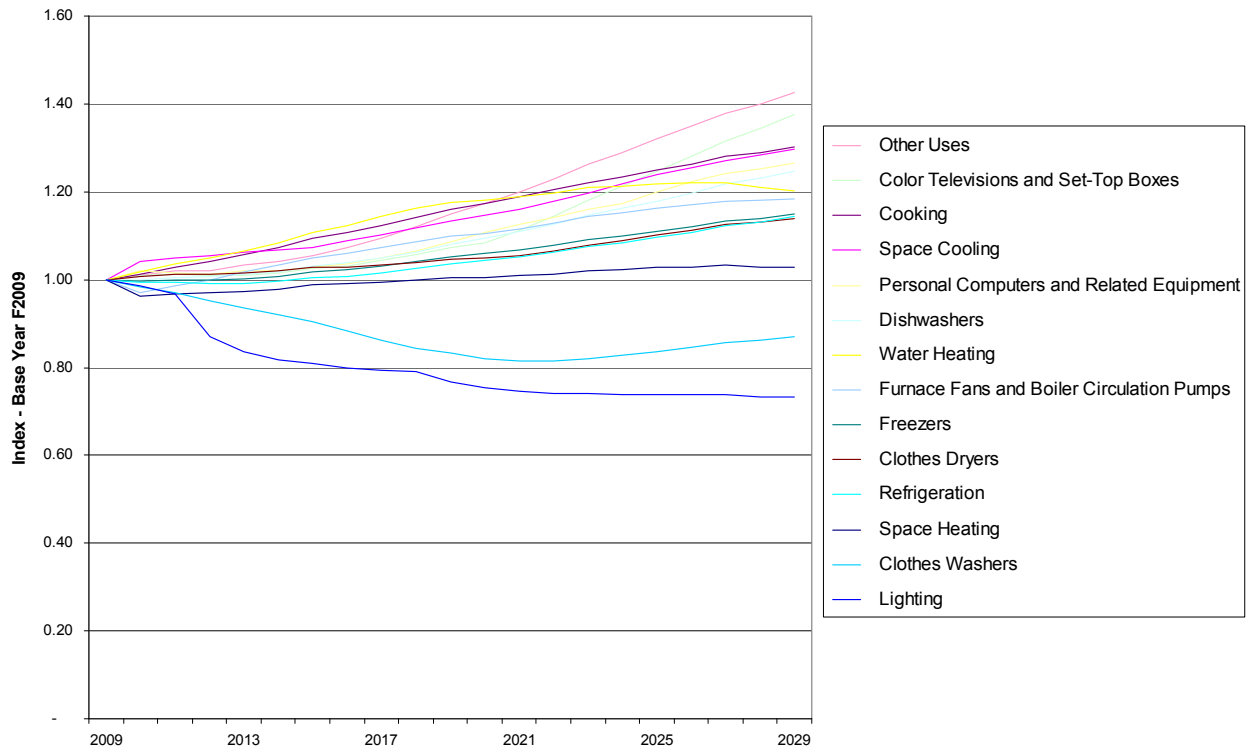


Figure 9 – EIA US End-Use Load Growth Forecasts

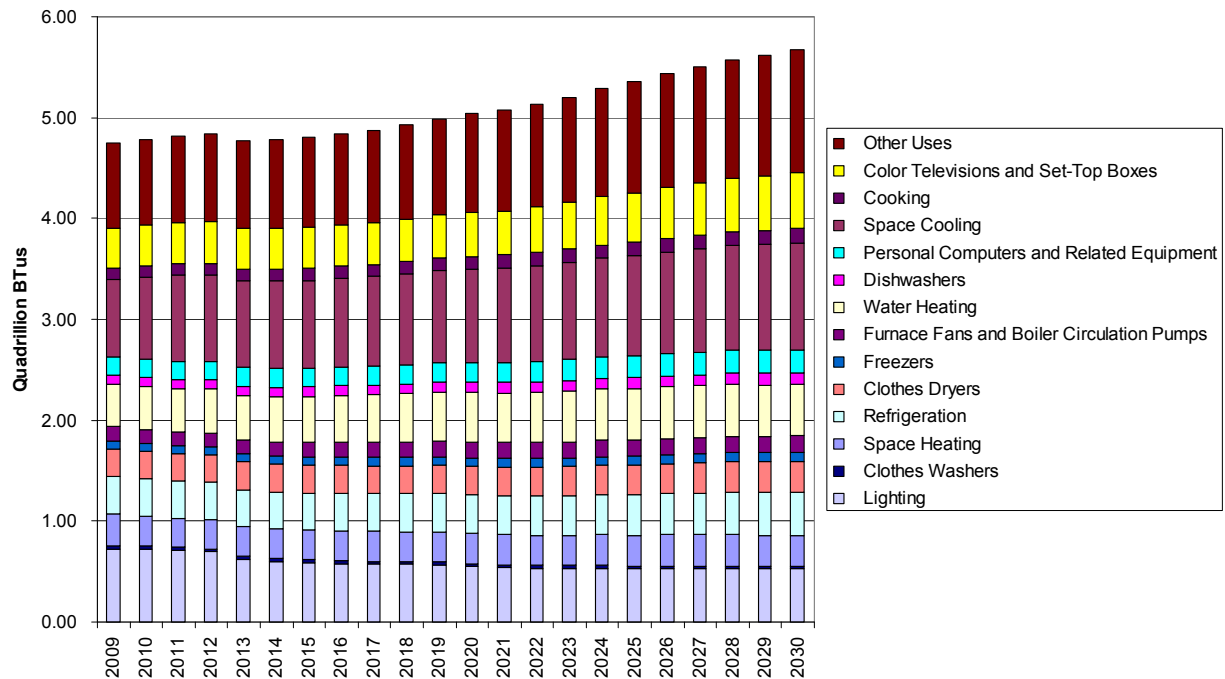


Figure 10 shows the breakdown of the EIA miscellaneous category.

Figure 10 – EIA Miscellaneous Electricity Uses in the Residential Sector

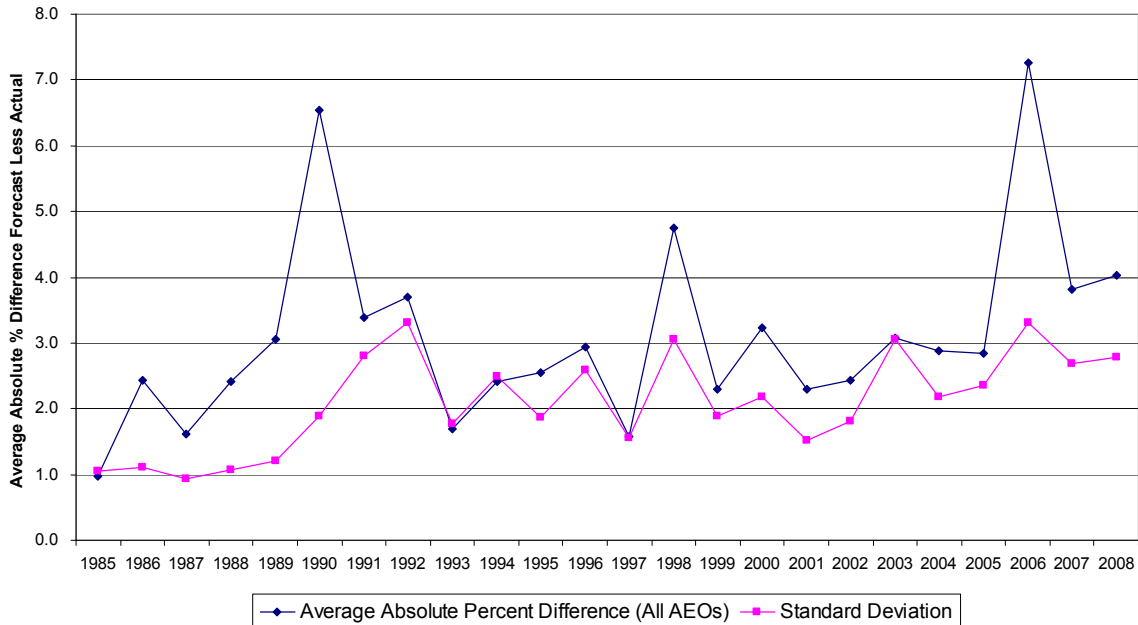
Table 5. Miscellaneous electricity uses in the residential sector, 2005, 2015, and 2030 (billion kilowatthours)

<i>Electricity use</i>	<i>2005</i>	<i>2015</i>	<i>2030</i>
<i>Coffee makers</i>	4.0	4.7	5.5
<i>Home audio</i>	11.8	12.6	14.0
<i>Ceiling fans</i>	16.8	20.1	23.5
<i>Microwave ovens</i>	14.3	16.3	19.0
<i>Security systems</i>	1.9	1.8	2.4
<i>Spas</i>	8.3	9.6	12.7
<i>Set-top boxes</i>	17.1	30.0	32.7
<i>Color TVs</i>	52.1	72.9	92.5
<i>Hand-held rechargeable devices</i>	9.8	9.0	10.6
<i>DVRs/VCRs</i>	15.6	12.0	9.8
<i>Total, miscellaneous uses studied</i>	151.7	188.9	222.7
<i>Other miscellaneous uses</i>	232.5	325.2	432.7
<i>Total miscellaneous</i>	384.2	514.1	655.4
<i>Total residential sector electricity use</i>	1,364.8	1,591.2	1,896.5

An additional analysis that can help inform the degree to which the forecast incorporates natural growth is to look at the historical accuracy of the EIA forecast to inform how well the EIA forecast captured growth in past forecasts. Figure 11 shows the historic accuracy of the EIA forecast. This figure shows the average of the absolute value difference of forecast less actual load over all available EIA forecasts for a given year, compared with the actual load,

based on the EIA 2009 Retrospective Analysis. The graph also shows the standard deviation of the accuracy of all vintages of forecasts for the given year. This graphs shows that on average the EIA has an average absolute forecast error of approximately 3% for any given year with an average standard deviation of 2%. Interestingly, the forecast error and standard deviation have tended to increase in later years.

Figure 11 – Historical Accuracy of EIA Forecasts – Absolute % Difference of Forecast less Actual



In summary, load growth in existing and miscellaneous new end-uses appears to be well addressed within the load forecast.

The DSM Plan incorporates some assumptions on natural growth through the process of modeling stock turnover in the codes and standards planning process. With DSM programs, the savings are typically a differential between the base technology and the efficient technology so natural growth is not addressed specifically. As with natural conservation, it is difficult to quantify the level of natural growth contained in the DSM Plan and the load forecast. The comparison of the level of natural growth between the DSM and load forecasting processes suffers from the same shortfalls as with natural conservation. There is no consistent planning framework between the two planning processes that allow a consistent quantification of the level of natural growth included in the forecasts.

In the short term it would be best to continue to improve sharing of planning inputs and work toward better integration in this area. In the long term this area should be addressed by developing a common planning framework and stock turnover model for DSM planning and load forecasting that will allow for a consistent level of natural growth to be included in the process.

Natural Growth – Significant New End Uses

As indicated above, the EIA forecast is based on a planning assumption that technologies which have not gained widespread acceptance today will generally not achieve significant penetration by 2030. Significant new end-uses such as electric vehicles are not included in the EIA reference forecast. In general, the EIA addresses significant new end-uses through the development of scenarios. The EIA also has a transportation sector where new end-uses such as electric vehicles are addressed in scenarios.

Using scenarios to address significant new end uses is a common approach throughout the electricity industry. BC Hydro also has used and plans to continue using a scenario approach to address significant new end-uses that involves both Load Forecasting and DSM planning.

BC Hydro should continue to examine the potential for new significant end-uses to influence the load forecast and the DSM Plan through a scenario approach. New end-uses should not be included in the reference load forecast until there is substantive evidence that they will be in the market place and that the end use will have a material impact on the load forecast.

3.3.3 Basic Stock Turnover

The BC Hydro before DSM load forecasting model relies upon the EIA stock turnover model output for average end-use efficiency values. This stock turnover model uses actual shipments of end-uses and surveys of end uses of electricity to calibrate the model for stock volume and efficiency levels. BC Hydro relies upon the component of the model that is calibrated to the Pacific Census Region, which includes the US states of Oregon, Washington, California, Alaska and Hawaii. The EIA model then simulates the timing of when end-uses would be replaced given equipment life expectancies and breakdown rates. Consumer life cycle cost economic equations are used to model consumer end use replacement and new purchase decisions.

British Columbia is geographically aligned with the EIA Pacific Census Region. Given that manufacturers do not manufacture separate equipment unique to British Columbia, it is fair to assume that the EIA assumptions around equipment related parameters such as equipment technical life, decay rates, usage intensities, replacement costs and new purchase costs are consistent with what would be expected in British Columbia.

The DSM planning process relies upon the conservation potential review (CPR) input from consultants, external reports and other analysis specific to the DSM program or initiative being planned. This is based on British Columbia data to the extent possible.

An area of concern with relying upon the outputs of the EIA basic stock turnover model for load forecasting is with the fuel price forecasts incorporated into the EIA model. Fuel price forecasts are included in EIA stock turnover models as they are a significant input to the life cycle cost economic equations that are used within the stock turnover models for simulating customer choices. Differentials in alternate fuel prices in a stock turnover model can influence which end-use replacement and new purchase options are selected by the model.

For example, if electricity prices are higher than gas prices, for an equivalent amount of energy, then a stock turnover model would be expected to choose gas equipment over electricity equipment. Given difference in relatively higher average embedded electricity prices in the US, compared with British Columbia, there may be less selection of electricity fuelled end-uses in the EIA stock turnover model than in British Columbia for end-uses that have non-electricity fuelled substitutes available in the market. As well, this may mean that when electricity end-uses are selected in the EIA model, they may tend to be more efficient than equivalent end-uses in British Columbia.

There may also be some consumer decision-making variables that are applicable in the US but which are not applicable in British Columbia influencing the EIA stock turnover model including influences from residential wind or solar installation incentives.

Overall, however, it is reasonable to assume in the short term that there is general alignment between the EIA stock turnover modeling results and the reality in British Columbia.

Not all DSM Planning processes are based on stock turnover modeling processes. However, where there is stock turnover modeling, the models are generally based on BC data, where possible. To this extent, it would be reasonable to assume some general consistency in basic stock turnover modeling between the DSM Planning and load forecasting processes. However, in the long term, BC Hydro should consider moving to a BC specific stock turnover model that will allow the incorporation of BC specific factors and which will allow alignment between the DSM planning and load forecasting processes in the area of basic stock turnover.

3.3.4 Price Elasticity

The load forecast includes natural price elasticity impacts to address the influence that overall real electricity prices have on the total sector load. This is termed rate impacts in the BC Hydro Annual Load Forecast document and it does not include the impact of conservation rate structures. From a load forecasting and DSM integration perspective, it is important that there is no natural price elasticity impact being assumed in the DSM planning process. This is the case and there is therefore, no inconsistency between load forecasting and DSM planning.

3.3.5 Conservation Rate Structures

The effect of conservation rate structures is included in the DSM Plan and is not included in the load forecast. Therefore, there is no misalignment between the load forecast and the DSM Plan with respect to rate structure elasticity. An allocation of rate elasticity impacts between natural price elasticity effects and conservation rate effects is undertaken that ensure no inconsistencies.

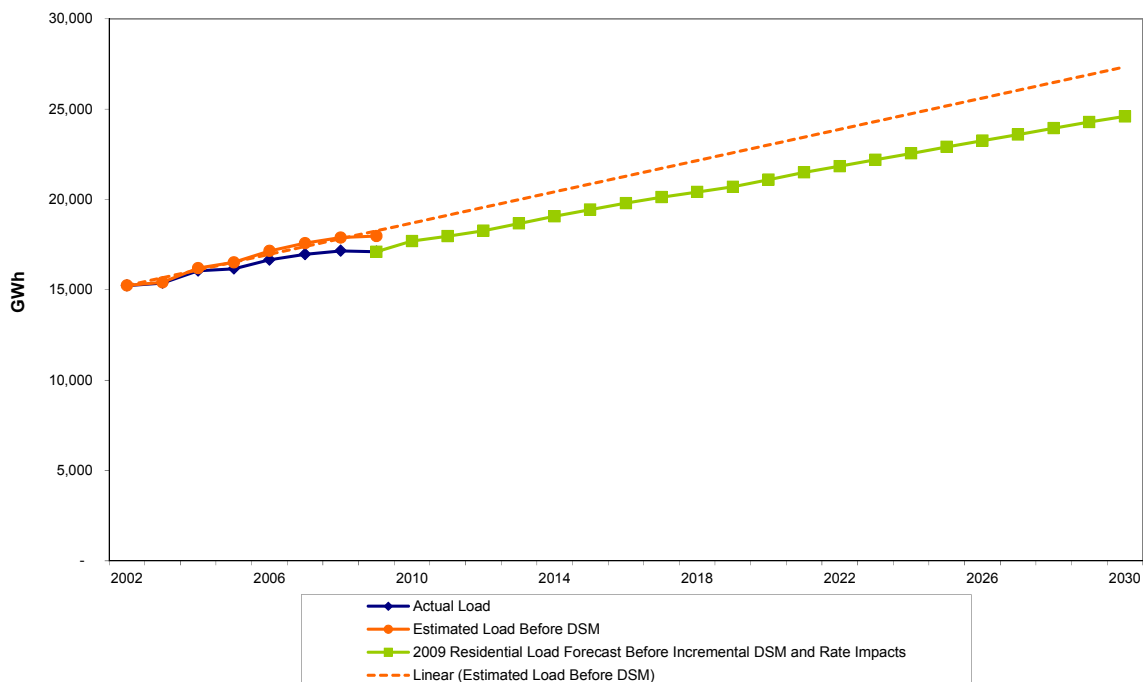
3.3.6 Historic DSM Impact

As indicated in Section 2.1.1, the use per account projection for the residential sector is prepared using a statically adjusted end-use model (SAE). This model's historic inputs include end-use efficiency values, saturation levels, weather and economic variables and

actual load. The process then relies upon forecast end-use efficiency values and saturation rates to make load projections.

There was a concern raised in the 2008 LTAP regulatory process that since the actual load that is included in the SAE forecasting model includes the impacts of historic DSM, the forecasting equations may contain a downward bias resulting in a load forecast that all else equal would be higher. This concern is depicted in Figure 12. In this figure, the actual load and an estimate of the actual load before DSM is shown with an associated extrapolation of these trends over the forecast horizon using linear regression. In simple terms, the concern can be demonstrated by the fact that the upper linear extrapolation line is higher than the lower linear trend line, leading to a perspective that if the historic DSM in the actual load is removed, or accounted for, the load forecast will be higher. The main misconception with this concern is that BC Hydro's load forecast is not prepared using linear regression methods. The key question to answer is whether or not the SAE model, and the associated inputs, that BC Hydro uses to prepare the load forecast is influenced or biased by the fact the actual load includes the impacts of historic DSM.

Figure 12 – Example of Historic DSM Concern



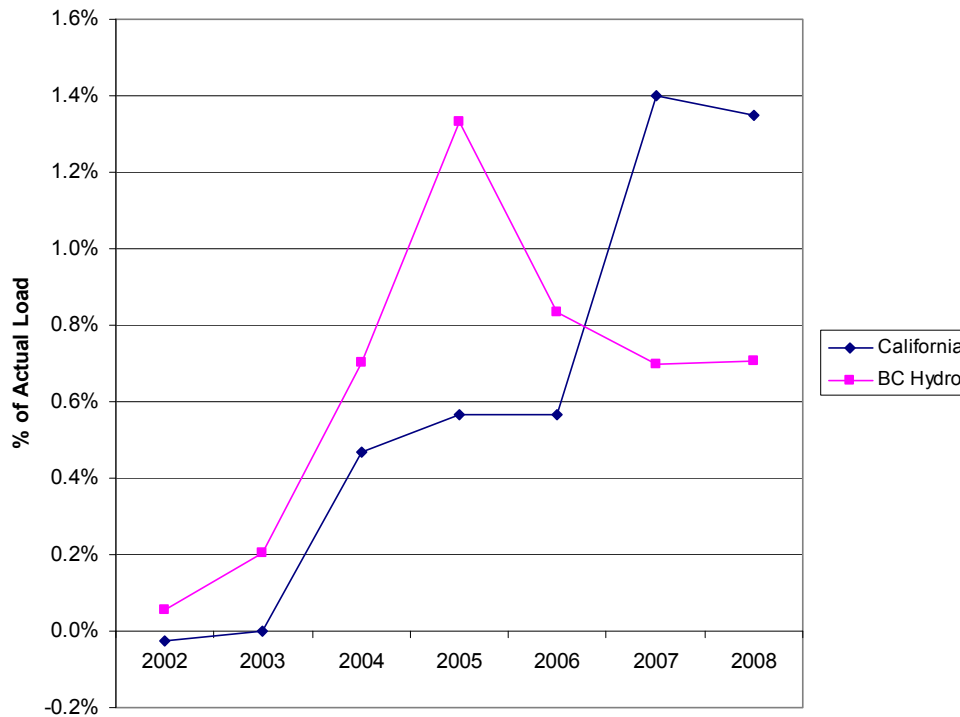
To explore this issue in detail, BC Hydro reviewed two alternative methodologies using the SAE model. The development of these methods was undertaken with assistance and guidance from Itron Inc., the developer of the SAE model.

In Method 1 (Add Back Method), the impact of past DSM is removed from actual load data. The actual load is increased by the level of historic DSM achieved, as provided by Power Smart. Using the SAE model, it would not be correct to then prepare a forecast by only adjusting the actual load data for historic DSM because historic efficiency values that are incorporated into the SAE model, based on EIA data, also include historic DSM influences.

A method of adjusting the EIA residential end-use unit energy values, as described below, is required to balance the historical influence of DSM in the SAE model. This means that both the actual sales (i.e. independent variable) would be adjusted by historical DSM and the EIA data included as explanatory variables in the SAE model would be adjusted by the impact of historic DSM.

The Pacific census region historic end-use efficiency values are calibrated by the EIA to reflect efficiencies of actual end-use shipments in the five states of the Pacific Census region. These shipments incorporate the impact of historic DSM efforts in the Pacific census region. The largest influence in the Pacific census region is California, which makes up approximately 75% of the Pacific census region by population. A method to adjust the EIA end-use efficiency values for historic DSM is to make the adjustment based on the level of historic DSM by end-use that has been achieved in British Columbia. This is only reasonable however, if the level of historic DSM achieved in California is similar to the level of historic DSM achieved in British Columbia. This comparison of historic DSM achievement is shown in Figure 19.

Figure 13 – Residential Incremental DSM Program Energy Savings as a Percentage of Actual Residential Load

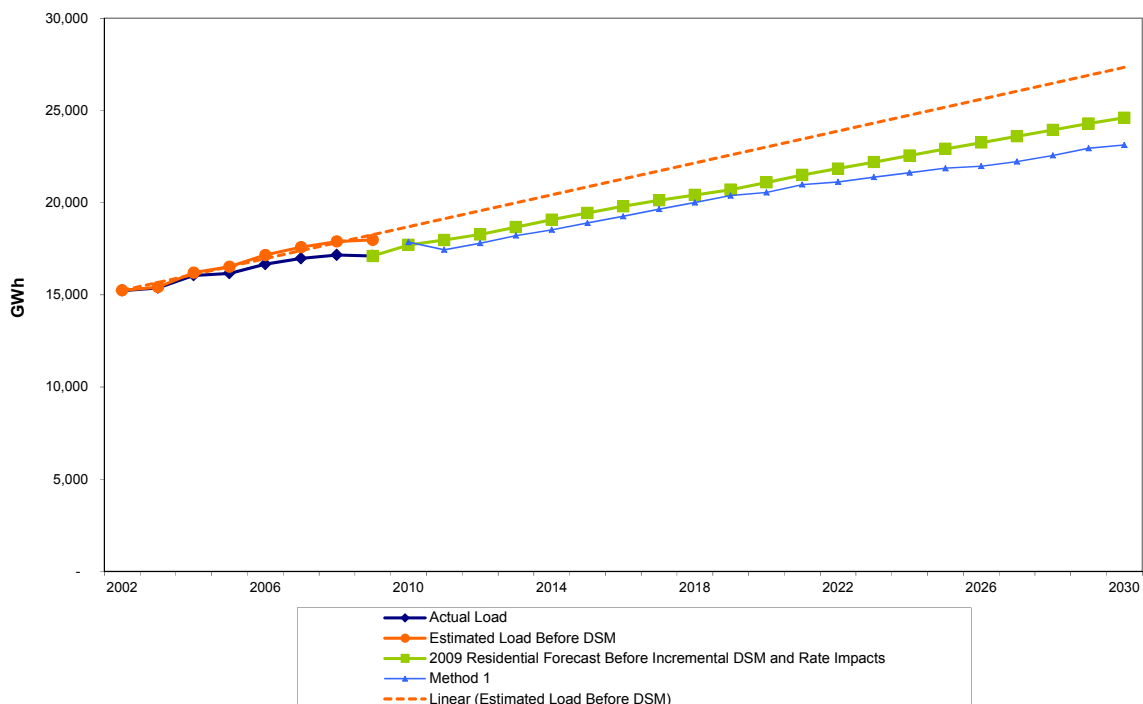


As shown above, there is some consistency in shape and magnitude of incremental DSM achieved in California and BC Hydro's service territory. Therefore, for the purpose of testing Method 1, the equivalent level of historic residential DSM reported by Power Smart on an end-use basis was removed from the EIA end-use efficiency values to approximate the level of historic end-use DSM embedded in the EIA values. Also, the estimated level of

persistence associated with this historic DSM by end-use was removed from the forecast EIA end-use efficiency values.

A Method 1 residential load forecast was then prepared using the adjusted actual residential load data and the adjusted EIA unit energy consumption values. Results of Method 1 forecast are shown in Figure 14. In this figure the Method 1 forecast is on the same basis as the 2009 Residential Forecast, in that it incorporates historic DSM persistence. Adjusting the actuals and adjusting EIA for historical DSM persistence puts the correct balance into the SAE regression model; both the independent and dependent variables are adjusted for past DSM. The forecast from Method 1 was then compared to the 2009 Residential Load Forecast to see how different the two forecasts would be.

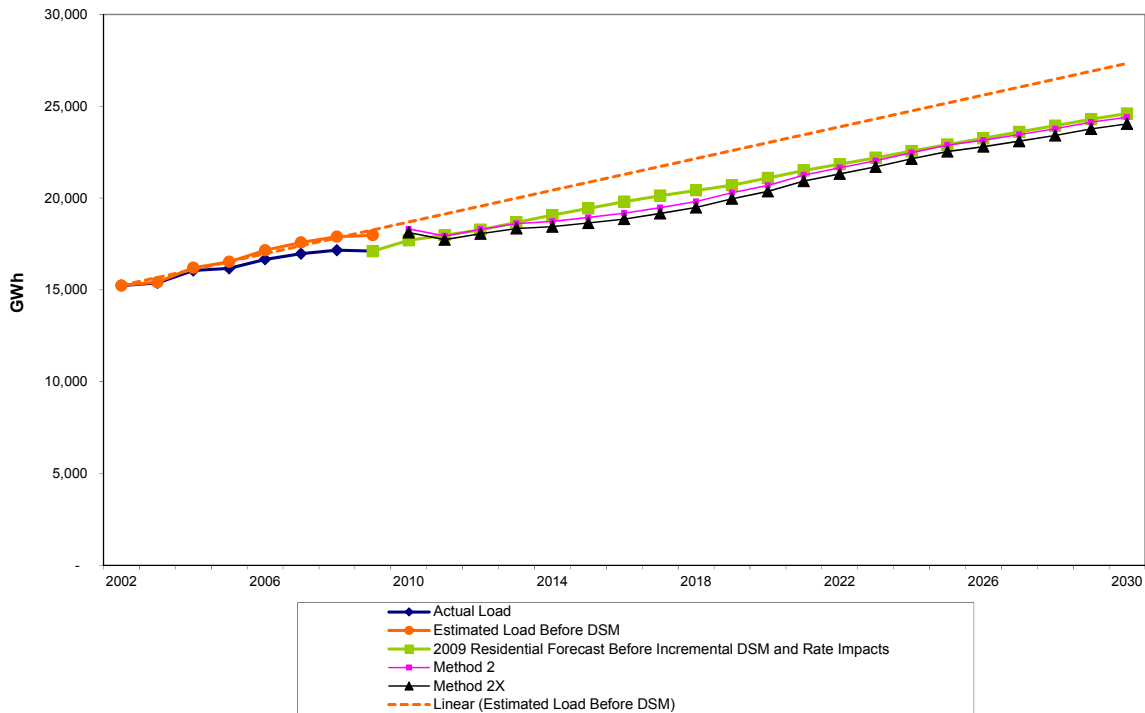
Figure 14 – Method 1 Load Forecast



As can be seen in Figure 14, Method 1 produces a load forecast that is similar to the residential load forecast, not a higher forecast as had been the concern. This is due to the fact that the historic EIA end-use unit energy consumption values include the impacts of historic DSM just as the actual BC Hydro residential load includes the influence of DSM. Removing the effect of historical DSM from the EIA values and actual load makes little difference to the load forecast. The Method 1 forecast is actually slightly lower than the original residential load forecast. This may be due to approximation methods used to adjust the EIA end-use values for historic DSM influences. As long as there is reasonable alignment between the level of historic DSM between the EIA Pacific Census region and British Columbia, Method 1 would be expected to provide a similar, if not the same, forecast as the current load forecasting methodology.

A second method of adjusting the SAE model to address the historic DSM concern was also tested. Method 2 (DSM Variable Method) involves incorporating a DSM variable into the SAE model equations. This method is ideally suited for a traditional econometric forecasting methodology, where there are no equivalent variables incorporated into the modeling methodology. In the context of the SAE model, adding a DSM variable has a limitation in that the SAE model forecast equations are developed using historic information that incorporates end-use efficiency values. These historic end-use efficiency values already include the effects of historic DSM. As such, a DSM variable is already implicitly included in the SAE model through the inclusion of historic EIA efficiency values. Therefore, if a DSM variable is added to the SAE model, the expectation is that the DSM variable would have low statistical significance. The result of Method 2 is shown in Figure 15. Statistical significance of the DSM variable in Method 2 is weak. The DSM variable in the northern region of the SAE model shows no statistical significance and the DSM variable for the other regions is low.

Figure 15 – Method 2 Load Forecast



Overall, Method 2, which includes the DSM variable, did not provide any additional explanatory power to the SAE model. To address the lack of statistical significance in the Northern region, a second forecast of Method 2 (shown as method 2X in Figure 15), was prepared. The Method 2X forecast uses the results for Method 2 for all regions except the Northern region. In Method 2X, the results of the Northern region are from the original load forecast. As shown, this method produces a load forecast that is slightly lower than the original forecast.

The results show that Method 2 and Method 2X produce a forecast that is very close the original 2009 residential forecast. This is not unexpected, as the 2009 residential load forecast SAE model already implicitly incorporates DSM in the historic period. This was also shown with Method 1.

In summary, there is no compelling reason to believe that the DSM inherently included in the BC Hydro historic load is unduly influencing the BC Hydro load forecast. The SAE model that BC Hydro uses to prepare the load forecast already reasonably incorporates the fact that DSM is included in historic load.

3.3.7 Incremental DSM Programs

DSM programs are used to advance the take up of more efficient technologies and practices and thereby drive energy savings. DSM programs can be used to help introduce new technologies into the market place and to increase the level of take up of these technologies to a point where new codes and standards can be implemented. If the EIA baseline level of efficiency is substantially different from the DSM plan baseline assumption, then there may be some inconsistency between the DSM plan and the Load Forecast. As discussed in the codes and standards section below, this may be the case for some end uses.

Where information is available and changes are practical, adjustments should be made to ensure Load Forecasting and DSM planning processes to use consistent planning assumptions regarding baseline efficiency levels. In the long term, a common planning framework and stock turnover model should be pursued.

3.3.8 Codes and Standards

Codes and standards are legally or regulatory required minimum end-use efficiency requirements that are in effect in a jurisdiction. The assumptions regarding current and future end-use efficiency codes and standards represent a potential area of overlap between the load forecast before DSM and the codes and standards savings as identified in the DSM Plan.

As indicated in Section 3.2, the EIA assumes that no new regulations beyond those currently embodied in law or new government programs fostering efficiency improvement will take place over the forecast horizon. The efficiency levels in the EIA UEC and EF data at the beginning of the EIA forecast period reflect average end-use efficiency in the market. The EIA stock turnover model forecasts replacement of end-use stock as it decays or reaches end of life with a new end-use that reflects at least the efficiency level embodied in current codes and standards, as per U.S. federal legislation and regulations known at the start of the forecast period.

The DSM Plan forecast of codes and standards energy savings assumes a baseline efficiency level over the forecast horizon. The DSM codes and standards energy saving are derived from expected improvements to this baseline as a result of codes and standards driven efficiency improvements over the forecast horizon.

The potential for overlap between the load forecast EIA based UEC and EF values and the DSM Plan centers around the potential for a different efficiency baseline assumption on codes and standards, as reflected in the DSM Plan, relative to the efficiency level of the codes and standards assumptions embedded in the EIA forecast.

A review of baseline codes and standards for many of the end-uses used in load forecasting and in the codes and standards DSM Plan is presented in Table 1.

Table 1 – EIA and BC Hydro Baseline Codes and Standards Efficiency Comparison

End Use	EIA Assumption	BC Hydro Baseline Assumption	Comments
Clothes Washer and Dryers	Modified Energy Factor ⁴ (MEF)=1.26	MEF=1.26	Based on an average clothes washer of 2.92Ft ² and average utilization of 392 times/year $MEF=C/(M+E+D)$; where C=Capacity of Clothes Contained, M=Sum of Machine Energy, E=Water Heating Energy and D=Energy required to dry clothes. EIA: per EIA 2009 Annual Energy Outlook (AEO) Appendix A: Consistent with the US Energy Independence Security Act of 2007 (EISA 2007) BC Hydro: MEF value shown on Power Smart Clothes Washer technical document and also calculated based on above MEF formula so demonstrate that Power Smart uses MEF of 1.26.
Refrigerators / Freezers	541 kWh/yr – refrigerator 436 kWh/yr – Freezer	484 kWh/yr – refrigerator 344 kWh/yr – Freezer	EIA: From EIA SAE average efficiency Input values for F19/20. This is used to represent marginal efficiency, largely driven by the effective code and standard in place today. EIA 2009 AEO Appendix A standards of 0.51 EF but cannot compare this to DSM Plan kWh/yr value. BC Hydro: Codes and Standards values from the codes and standards model.
Dishwasher	355 kWh/year (0.46EF)	360 kWh/year	EIA: From EIA 2009 AEO Appendix A. This is consistent with EISA 2007. BC Hydro: Values from the codes and

⁴ An energy efficiency descriptor that takes into account the remaining moisture content of clothes leaving the clothes washer

End Use	EIA Assumption	BC Hydro Baseline Assumption	Comments
			standards model
Electric Water Heater	0.9EF	0.9EF	EIA: From EIA 2009 AEO Appendix A BC Hydro: Uses savings associated with Minimum Efficiency Energy Performance Standards savings. This analysis assumes base efficiency of 0.9EF used.
Portable AC Units	9.8 EER	9.8 EER (assumed)	EER: The Energy Efficiency Ratio (EER) is determined by dividing the cooling capacity in Btu per hour by the power input in watts at any given set of rating conditions, expressed in Btu per hour per watt EIA: From EIA 2009 AEO Appendix A. This is current federal standard and not Energy Star. BC Hydro: Assumed to be current federal standard based on calculations and statements in the codes and standards model.
Lighting	General Service Incandescent Lamps – EISA 2007 standard of maximum wattage limits for lumen ranges as per: Lumens/ Max Wattage 1490-2600/72 1050-1489/53 750-1049/43 310-749/29 Fluorescent Lamp Ballasts – 0.90 power factor Torchiere Lamp Standard – 190 watt bulb limit in 2006.	General Service Incandescent Lamps – Average stock of current bulb wattages at current standards Fluorescent Lamp Ballasts – 32W T8 standard with natural adoption of 30W T8 lighting occurring Torchiere Lamp Standard – All replacements with 55W units	EIA: General Service Incandescent Lamp Standard is addressed by EIA with new bulb wattage reduced by 28 percent in 2013 and by 67 percent in 2020. Fluorescent lamp ballast standard as per EIA stated current standard Torchiere Lamp Standard as per EPACT05 BC Hydro: Per codes and standards model. The analysis assumes the BC Hydro Codes and Standards energy savings for lighting mimics the 2007 EISA standard implementation. Based on the comparison, there is at least double counting of energy savings with the GS incandescent lamps. Additional effort would be required to reconcile the fluorescent and torchiere baseline assumptions.

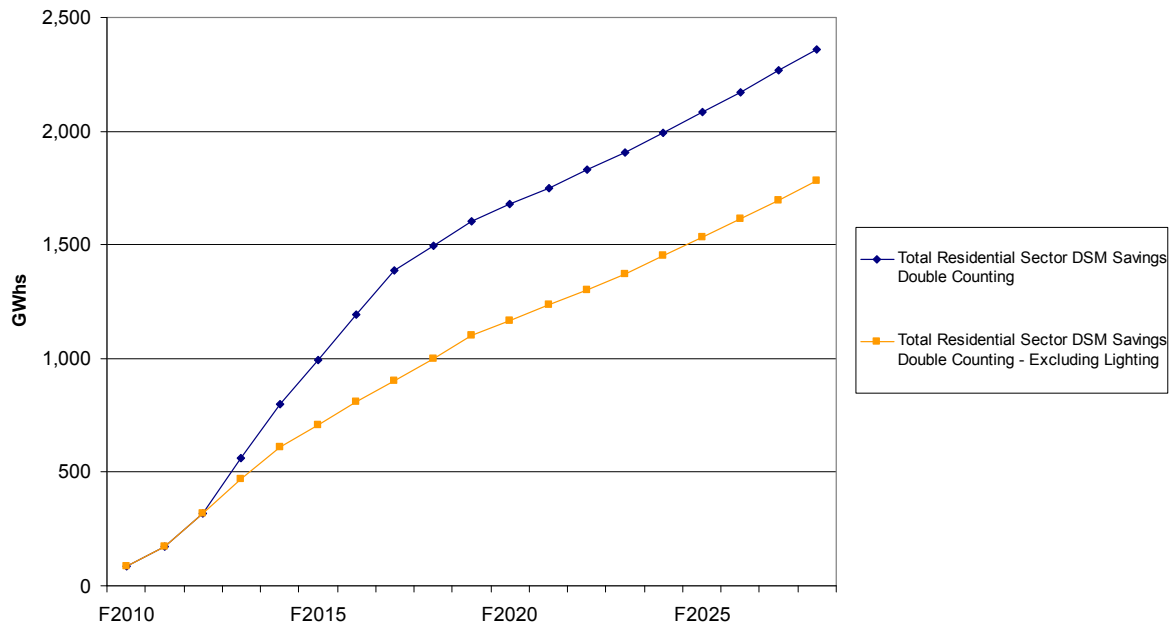
End Use	EIA Assumption	BC Hydro Baseline Assumption	Comments
Set-top boxes	Based on a projection of efficiency through 2030 by TIAX for EIA. Assumes all new TVs will have a decoder built in after 2015. Assumed to be 2007 Energy Star Active<=8W Standby <=1W Auto power down after 4 hours or less of user inactivity	Active<=8W Standby <=1W	Given that EIA is a projection of efficiency and there is minimal growth after 2015, the set-top box codes and standards savings are likely double counted.
External power supplies	Active Mode: < 1 watt-0.5 times the Nameplate Output (NO) 1 watt < or = 51 watts – Sum 0.09 tine the Natural Logarithm of NO + 0.5 >51 watts – 0.85 No Load: <250 watts – 0.5 watts	Not explicitly provided. The DSM Codes and Standards plan baseline is an estimate of the Non-Energy Star efficiency level included in the estimated savings provided by a report by the Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley national Laboratory, University of California entitles "Savings Potential of Energy Star External Power Adapters and Battery Charges"	The external power supplies Codes and Standards DSM savings are double counted as the target in the University of California report is the Energy Star level included in the EISA 2007, EIA baseline assumption. The DSM Plan does not provide any energy savings above this Energy Star level.

End Use	EIA Assumption	BC Hydro Baseline Assumption	Comments
Battery chargers	Per EISA 2007	Same as External Power Supplies	Energy savings are double counted as per External Power Supplies
TV	2009 Assume Energy Star Tier 1 Using 37.6 LCD TV as per Power Smart: ≤ 1 Watt in standby mode $P_{Max} = 0.200 * A + 32$	37.6 LCD TV baseline $P = 0.24A + 30.81$ Reference Screen @ Power On = 175.8 W From PG&E Report	The EIA baseline Power Smart codes and standards baseline is less efficient than the EIA baseline assumption. The DSM Codes and Standards plan targets: Tier I: $P = 0.16A + 28.17$ Tier II: $P = 0.12A + 25$ Therefore, approximately 50% of the DSM Tier 1 target energy savings are double counted.
Stand-by Power	Included in specific end-uses as above	Included in specific end uses as above	The proportion of stand-by power energy savings included in the DSM Plan is double counted as per the proportion of above end-use energy savings that are double counted.

As shown in Table 1, there are several areas of difference in baseline assumptions between the EIA and the Power Smart. This results in the double counting of energy savings between the load forecast and the DSM Plan.

Figure 16 shows the level of energy savings that are considered to be double counted over the forecast horizon, based on the 2008 LTAP Evidentiary Update codes and standards DSM Plan. This level of duplicated energy savings was determined by summing the level of energy savings included in the DSM Codes and Standards Plan for each of the above end-uses. Only a portion of the end-use savings was included when there was partial double counting.

Figure 16 – DSM Codes and Standards Energy Savings Considered to be Included in the Residential Before Incremental DSM Load Forecast



It has been assumed in this analysis that the codes and standards compliance levels between the US Pacific Census Region and BC are similar.

In summary, based on available information there is approximately 1,700 GWh of energy saving double counting between the residential DSM codes and standards energy savings and the load forecast in F2020. An adjustment has been made to the 2010 load forecast to address this double counting.

3.3.9 Efficiency Rebound Effect

The EIA forecast assumes an efficiency rebound effect which is implicitly incorporated in the before DSM load forecast to represent an increase in load associated with improvements in efficiency over the forecast horizon in the before DSM load forecast. The DSM planning process incorporates an efficiency rebound impact associated with DSM driven efficiency improvements. Therefore, there is no structural double counting of efficiency rebound effects between the before DSM and rate impact load forecast and DSM programs.

3.4 Residential Sector Issues and Recommendations

Table 2 outlines the main issues that have been identified in this review of the residential sector along with alternate approaches to addressing these issues and a recommendation is provided.

Table 2 – Summary of Findings, Alternate Approaches and Recommendations for the Residential Sector

Load Forecast Component	Main Finding
Natural Conservation	
Issue(s)	Although natural conservation is recognized in both the DSM Plan and the Load Forecast, it is difficult to fully quantify the relative level of natural conservation included in each. Material inconsistencies in natural conservation assumptions could lead to the under or over counting of load.
Alternate Approaches	<u>Short Term</u> There are two short term alternatives to address the natural conservation issue: 1. Continue planning using current processes. 2. Continue planning using current processes and work toward improved sharing of planning assumptions between the DSM planning and load forecasting groups to support better alignment on natural conservation where possible. Continue to pursue additional clarity on marginal efficiency values from the EIA which will support quantifying natural conservation in the Load Forecast. <u>Long Term</u> The alternatives for the long term are: 1. Continue with the chosen short term solution. 2. Develop a common planning framework and stock turnover model for load forecasting and DSM planning with consistent inputs.
Recommendation	In the short term, recognize that both planning processes incorporate some natural conservation and work toward better integration on this issue. In the long term, develop a common planning framework and stock turnover model between load forecasting and DSM planning to align the area of natural conservation.
Natural Growth	

Load Forecast Component	Main Finding
Issue(s)	Load growth associated with existing and miscellaneous new end-uses appears to be reasonably well addressed within the Load Forecast. The DSM Plan also incorporates assumptions on natural growth. However, as with natural conservation, it is difficult to thoroughly quantify the relative amount of natural growth contained in each forecast.
Alternate Approaches	<u>Short Term</u> There are two short term alternatives to address the natural growth issue: 1. Continue planning using current processes. 2. Continue planning using current processes and work toward improved sharing of planning assumptions between the DSM planning and load forecasting groups to support better alignment on natural growth where possible. The alternatives for the long term are: <u>Long Term</u> 1. Continue with the chosen short term solution. 2. Develop a common planning framework and stock turnover model for load forecasting and DSM planning with consistent inputs.
Recommendation	In the short term, recognize that both planning processes acknowledge natural growth and work toward integration on this issue. In the long term, develop a common planning framework and stock turnover model to align the area of natural growth.
Basic Stock Turnover	
Issue(s)	It is reasonable to assume close general alignment between the Energy Information Administration (EIA) stock assumptions for the US pacific census region and those in British Columbia. This is why the EIA assumptions are used in BC Hydro's load forecasting process as a proxy for British Columbia stock turnover. However, there may be the potential for some differences in these assumptions due to the following: 1) Differences in fuel prices between US and British Columbia may result in the EIA Unit Energy Consumption (UEC) and Efficiency Factor (EF) values being more efficient in the US than in British Columbia. US electricity prices, which are higher than in BC, may drive more efficient electricity technologies than what may otherwise occur in British Columbia. 2) Stock turnover in the US pacific census region may be based on

Load Forecast Component	Main Finding
	regional consumer decision making variables that that are somewhat different than in British Columbia. Not all BC Hydro DSM planning processes are based on stock turnover modeling. However, where this occurs, the models are generally based on BC data - where possible. To this extent, it would be reasonable to assume general consistency in stock turnover modeling between BC Hydro DSM Planning and load forecasting processes given the above aspects of the EIA stock turnover model.
Alternate Approaches	<u>Short Term</u> In the short term, the only viable option is to continue using the EIA data for the before DSM and rate load forecasting process. <u>Long Term</u> There are three options to address stock turnover issues in the longer term. 1. Continue to use the EIA model as an input to the before DSM and rates load forecasting process; 2. Develop a BC Hydro stand-alone load forecasting stock turnover model for the before DSM and rates load forecasting process; and 3. Develop a common planning framework and integrated load forecasting and DSM forecasting stock turnover model that would provide the functionality of alternate 2 but also include the planning requirements for DSM. This would ensure unified data and assumptions between Load Forecasting and DSM planning.
Recommendation	There should be relatively close alignment between the US-based EIA and BC-specific stock options. However, to minimize the possibility of inconsistencies between basic stock turnover assumptions, alternative 3 is recommended.
Price Elasticity	
Issue(s)	The BC Hydro load forecast includes adjustments due to price elasticity effects. These arise from overall electricity rate level adjustments (Real \$), and are distinct from the effects from Conservation Rate Structures (see below). Therefore, there is alignment between Load Forecasting and DSM Planning in this area.
Alternate Approaches	No alternatives are required.
Recommendation	No actions required.

Load Forecast Component	Main Finding
Conservation Rate Structures	
Issue(s)	The DSM plan includes load adjustments due to the effects of conservation rate structures. These are distinct from the price elasticity effects that the Load Forecasting group includes in their load forecast. Therefore, there is alignment between Load Forecasting and DSM Planning in this area.
Alternate Approaches	No alternatives are required.
Recommendation	No actions required.
Historic DSM	
Issue(s)	Regression-based load forecasting models can be susceptible to the effects of historic DSM savings, including the potential for double counting of DSM savings. However, the statistically adjusted end-use model that BC Hydro uses to prepare the residential load forecasts appropriately incorporates the effects of historical DSM appropriately, such that there is no concern of double counting.
Alternate Approaches	No alternatives are required.
Recommendation	No actions required.
Incremental DSM Programs	
Issue(s)	There is some potential for inconsistency between the load forecast and the DSM Plan related to the inconsistency identified with program planning assumptions. If the EIA baseline efficiency level is different than what is assumed in the DSM baseline, then there may be some DSM savings double or under counting.
Alternate Approaches	<u>Short Term</u> Where information is available and changes are practical, adjustments will be made to ensure load forecasting and DSM planning processes use consistent planning assumptions regarding baseline efficiency levels. <u>Long Term</u> Develop a common planning framework and stock turnover model that will be used for both DSM planning and load forecasting processes.

Load Forecast Component	Main Finding
Recommendation	Where information is available and changes are practical, adjustments will be made to ensure load forecasting and DSM planning processes use consistent planning assumptions regarding baseline efficiency levels. In the long term, develop a common planning framework and stock turnover model that will be used for both DSM planning and load forecasting processes.
Codes and Standards	
Issue(s)	Future DSM savings attributable to new codes & standards are forecast against baseline assumptions of expected future stock energy consumption and efficiency levels. If the EIA baseline assumptions used in the load forecast are substantially different from the DSM plan baseline assumptions, then there may be some double or under counting between the DSM plan and the load forecast. Double counting of DSM energy savings in the residential sector Load Forecast for some end uses has been positively identified. This is because codes & standards efficiency gains attributed as DSM savings are already included in the EIA assumptions that are used to prepare BC Hydro's residential sales forecasts. Based on the analysis undertaken by BC Hydro, the double counting amounts to approximately 1,700 GWh in F2020 for the residential sector.
Alternate Approaches	<u>Short and Long Term</u> If the EIA data is to be used on an ongoing basis, the baseline assumptions of codes and standards between EIA and DSM planning should be monitored on an ongoing basis. In the short term, any double counted energy saving should addressed in the before incremental DSM load forecast, provided these savings continue to be included in the DSM plan. In the long term, the development of a common planning framework and stock turnover model would address this issue.
Recommendation	In the short term, make the necessary adjustments to the Load Forecast to account for the codes and standards double counting. Ongoing effort will be required to ensure alignment between the EIA and DSM plan codes and standards efficiency level assumptions in future versions of the BC Hydro Load Forecast. In the longer term pursue the development of a common planning

Load Forecast Component	Main Finding
	framework and stock turnover model that would be used for load forecasting and codes and standards planning, incorporating consistent planning assumptions.
Efficiency Rebound Effect	
Issue(s)	There is structural alignment of efficiency rebound effects between the load forecast and the DSM plan.
Alternate Approaches	No alternatives required.
Recommendation	No actions required.

4.0 Commercial Sector

4.1 BC Hydro Commercial Sector DSM Plan

The DSM savings will be achieved through DSM programs, rate structures and codes and standards. These are described below. There are also supporting initiatives for the overall DSM Plan.

Commercial DSM Programs – There are 6 DSM programs that generate savings in the commercial sector:

1. Power Smart Partner
2. Product Incentive
3. New Construction
4. Voltage Optimization
5. Sustainable Community
6. Load Displacement

Rate Structures – Revised rates structures designed to encourage conservation.

Codes and Standards – More efficient codes and standards are included in the DSM Plan that target building codes, commercial equipment (high intensity discharge lamps and ballasts, packaged terminal air-conditioners, ice-cube makers, large air-conditioners, commercial clothes washers) and appliances.

4.2 EIA Commercial Forecast

The EIA follows similar principles in preparing the commercial load forecast as with the residential forecast, outlined in section 3.2.

The EIA commercial efficiency forecast is undertaken for eleven building categories and for ten end-use services across nine census regions. The commercial model begins by developing projections of floor space for the 99 building category and census division combinations. Next, the ten end-use service demands required for the projected floor space are developed. Then projections of distributed generation are made. Technologies are then chosen to meet the projected service demands for the seven major end-uses. Once technologies are chosen, the energy consumed by the equipment stock (both existing and purchased equipment) is developed to meet the projected end-use service demands.

4.3 Commercial Distribution Sector Key Issues

4.3.1 Natural Conservation

The main points regarding commercial sector natural conservation are the same as those captured in section 3.3.1 for the residential sector with the same alternatives to moving forward.

4.3.2 Natural Growth

The same concepts of natural growth apply to the commercial sector as in the residential sector.

The “Other” category of the “Miscellaneous” category in the EIA forecast captures growth of new end uses in the commercial sector. Figure 17 shows the breakdown of the miscellaneous sector of the 2009 EIA AEO in the commercial sector.

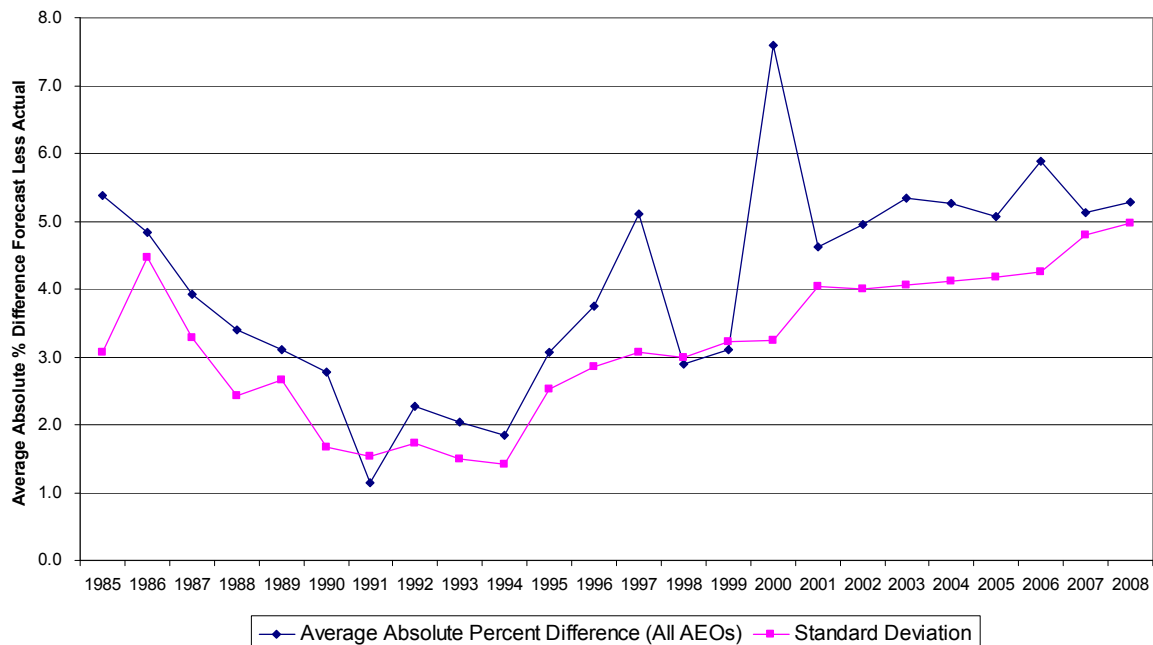
Figure 17 – EIA Miscellaneous Electricity Uses in the Commercial Sector

Table 7. Miscellaneous electricity uses in the commercial sector, 2005, 2015, and 2030 (billion kilowatthours)

Electricity use	2005	2015	2030
Coffee makers	2.7	3.0	3.5
Distribution transformers	54.5	54.6	54.9
Non-road electric vehicles	4.0	5.1	7.1
Magnetic resonance imaging (MRI)	0.6	1.9	4.5
Computed tomography (CT) scanners	0.9	1.8	2.8
X-ray machines	4.0	6.8	12.0
Elevators	4.4	4.7	5.5
Escalators	0.7	0.8	1.0
Water supply: distribution	40.0	42.0	47.0
Water supply: purification	1.1	1.2	1.3
Wastewater treatment	24.5	25.3	27.2
Total, miscellaneous uses studied	137.4	147.2	166.8
Other miscellaneous uses	229.5	357.9	601.6
Total miscellaneous	366.9	505.1	768.4
Total commercial sector electricity use	1,266.7	1,548.2	2,061.6

Figure 18 shows the historical accuracy of the EIA commercial sector forecasts. Although not forward looking, this demonstrates the degree to which the EIA has been accurate in capturing natural growth in past forecasts. For absolute average forecast error for any given year has been 4.1% with a standard deviation of 3.2%.

Figure 18 – EIA Historical Commercial Sector Forecast Accuracy



4.3.3 Basic Stock Turnover

The EIA commercial model has two main stock turnover dimensions. There is stock turnover related to floor space and also stock turnover related to the equipment required to provide services to the commercial buildings.

EIA existing floor space assumptions are estimated based on a survey. Over time, floor space stock is projected to decline as buildings are removed from service (floor space attrition). Floor space attrition is estimated by a logistic decay function in the EIA model, the shape of which is dependent upon two parameters: the median expected lifetime of a particular building type and the rate at which buildings retire near their median expected lifetime. By combining the surviving floor space estimates with the total floor space projection from a macro economic model, new construction estimates can be developed.

Once the floor space projection is developed, a projection of the service demands for energy-consuming services is undertaken. Service demands are developed for space heating, space cooling, ventilation, water heating, lighting, cooking, refrigeration, personal computer office equipment and other office equipment. The service demand intensity (SDI), measured in 10^3 Btu of end-use service demand per square foot, differs across service, Census division and building type. Projected service demand is the product of square feet and SDI for all end uses across the eleven building categories with adjustments for changes in shell efficiency for space heating and cooling.

Shell efficiency is an important determinant of the heating and cooling loads for each building type.

The EIA commercial model incorporates a projected contribution of distributed generation and combined heat and power (CHP) technologies based on economic returns of these technologies.

A technology choice sub module is then used to select equipment based on capital purchase decisions for the three major fuels (electricity, natural gas and distillate fuel). Capital purchase decisions are driven by assumptions concerning behavioural rule proportions and time preferences, as well as projected fuel prices, average utilization of equipment (the capacity factors), relative technology capital costs, and operating and maintenance (O&M) costs. In each projection year, equipment is selected for newly added equipment, equipment that is expected to wear out and for equipment that has become technologically obsolete.

In summary, the EIA model for commercial floor space and equipment turnover is a sophisticated and reasonable model for predicting reality in the Pacific census region. Given that British Columbia is well situated geographically in the Pacific census region, the EIA commercial model may be reasonable for predicting the commercial floor space and equipment stock turnover in British Columbia. Two areas of potential concern however, are:

- The electricity prices in the Pacific census region are relatively higher than the electricity prices in British Columbia. Therefore, the EIA commercial stock turnover

model may select more efficient electricity end-uses than what would be expected in British Columbia; and

- The level of macro-economic activity in the Pacific census region could diverge at times from the level of economic activity in British Columbia. As a result there may be temporal misalignments between the EIA model and reality in British Columbia. This is somewhat addressed by BC Hydro in that B.C. economic data is incorporated into the SAE model when preparing the commercial distribution load forecast.

Not all DSM Planning processes are based on stock turnover modeling processes. However, where there is stock turnover modeling, the models are generally based on BC data, where possible. To this extent, it would be reasonable to assume some general consistency in stock turnover modeling between the DSM Planning and load forecasting processes. However, there is some uncertainty to this assumption and in the long term, BC Hydro should move to a BC specific stock turnover model that will allow the incorporation of BC specific factors and which will allow alignment between the DSM planning and load forecasting planning processes in the area of baseline stock turnover.

4.3.4 Price Elasticity

As with the residential sector, the commercial sector load forecast includes price elasticity impacts to address the natural influence that overall changes in real electricity prices have on the load. This is termed price elasticity in this paper and does not include the impact of conservation rate structures and how consumers may change their consumption behaviour in response to those rate structures. From a load forecasting and DSM integration perspective, it is important whether there is any price elasticity impact being assumed in the DSM planning process. This is the case and there is therefore, no inconsistency between load forecasting and DSM Planning.

4.3.5 Conservation Rate Structures

Conservation rate structures are in place for the General >35kW service category. There is no double counting between these rate structure impacts included in the DSM Plan and the load forecast.

4.3.6 Historic DSM Impact

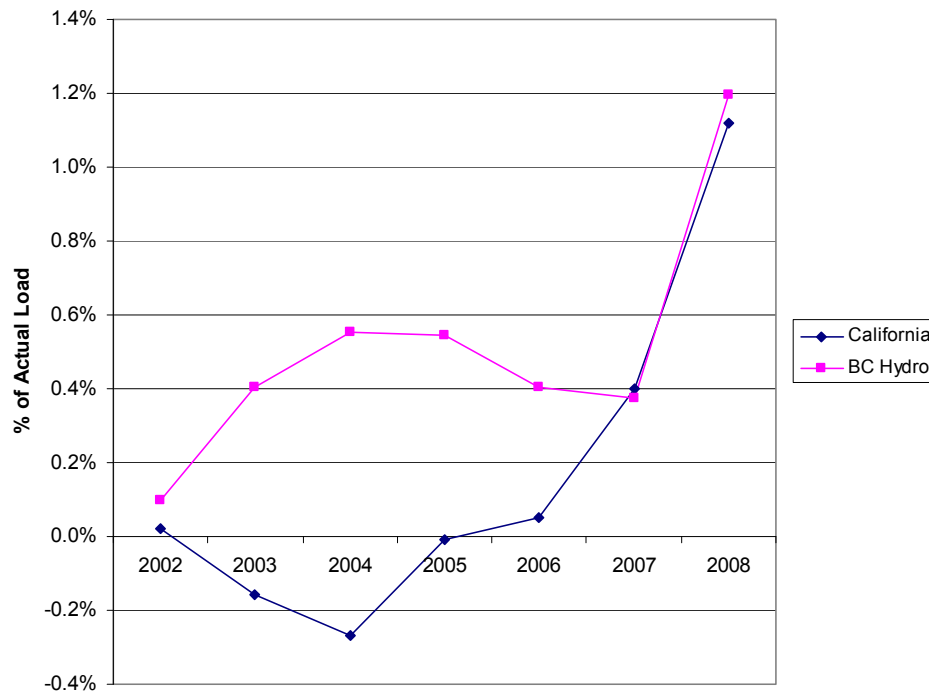
BC Hydro uses the SAE model to prepare the commercial distribution voltage load forecast. As such, the discussion for the residential sector also applies to the commercial sector.

BC Hydro tested Method 2 in the commercial sector. Method 1 was not tested for the commercial sector due to difficulties in adjusting the SAE model historic efficiency values to account for historic DSM impacts.

Figure 19 shows a comparison between the historic level of achieved DSM savings in California as reported by the California Energy Commission⁵ and the BC Hydro commercial sector DSM Program savings. There is some general alignment in the early and later parts of the 2002 to 2008 time period with some divergence in the middle portion of this period.

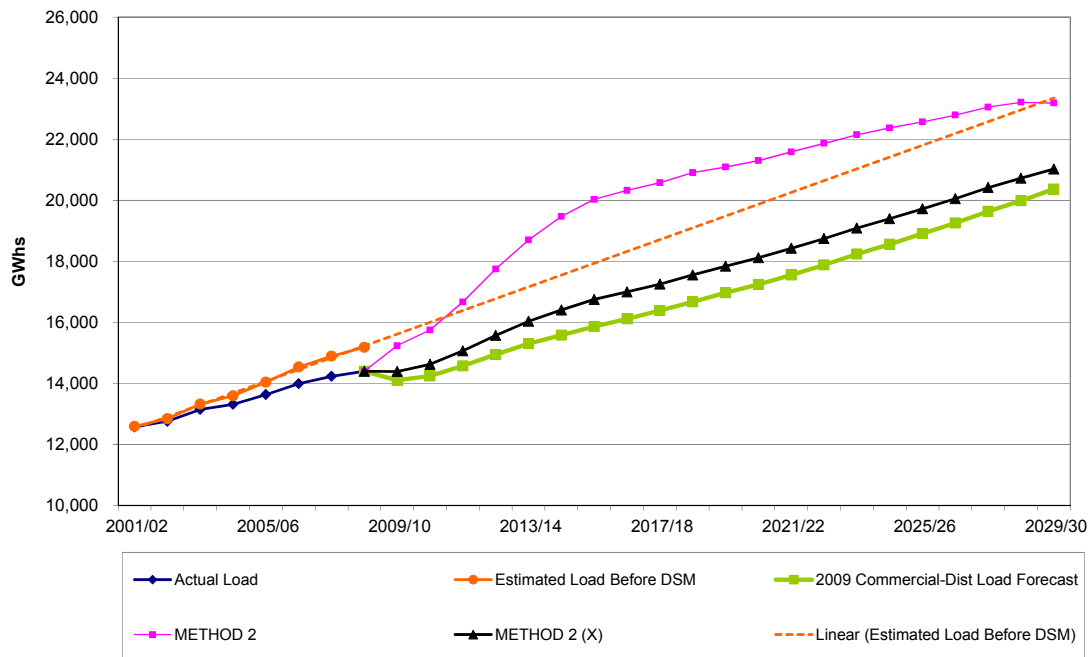
⁵ California Energy Demand 2010-2020 Staff Revised Forecast

Figure 19 – Commercial Distribution Voltage Sector Incremental DSM Program Energy Savings as Percentage of Actual Commercial Load



The result of Method 2, displayed in Figure 20, shows the impact on the commercial distribution voltage load forecast when a DSM variable is added to the model. As expected with Method 2, the statistical significance of the DSM variable is low. Within the results of Method 2, in the Lower Mainland region, the DSM variable is not statistically significant for the General < 35kW and General >35kW rate classes. The DSM variable is also not statistically significant for the Vancouver Island region for the General >35kW rate classes. The statistical significance of the DSM variable for the remaining regions is weak. The higher forecast with Method 2 may be due to a lower level of DSM in the historic period in the EIA model, largely based on California data, than in the BC Hydro actual sales data. This has not been investigated further however. Regardless, the low statistical significance of the DSM variable with Method 2 provides sufficient reason to reject this forecast.

Figure 20 – Commercial Distribution Load Forecast – Method 2



Overall, there is not sufficient rationale to support including a DSM variable in the commercial distribution voltage SAE model for the following reasons:

- The change in the commercial distribution voltage load forecast as a result of implementing Method 2 is small;
- The current load forecasting model provides relatively high explanatory power; and
- Adding a DSM variable increases the complexity of the forecasting model with little benefit.

4.3.7 Incremental DSM Programs

The EIA does not specifically include DSM programs in the commercial sector. There is however, still a potential for inconsistency between the load forecast and the DSM Plan as a result of the inconsistency identified with baseline assumptions. If the EIA baseline efficiency level is higher than what is assumed in the DSM baseline, then there may be some DSM program double or under counting.

4.3.8 Codes and Standards

The EIA assumes that no new regulations beyond those currently embodied in law or new government programs fostering efficiency improvement will take place over the forecast horizon. In the commercial sector, the building shell efficiency standard is a major driver of the forecast for heating and cooling loads. End-use efficiency standards are also important.

The potential for inconsistency between EIA data and the DSM Plan in the area of codes and standards revolves around the potential for having differing assumptions on codes and standards between the EIA and the baseline incorporated into the DSM codes and

standards planning model. As most of the DSM Plan codes and standards related energy savings in the commercial sector are associated with the building shell and general service incandescent lighting, this review only addresses these components.

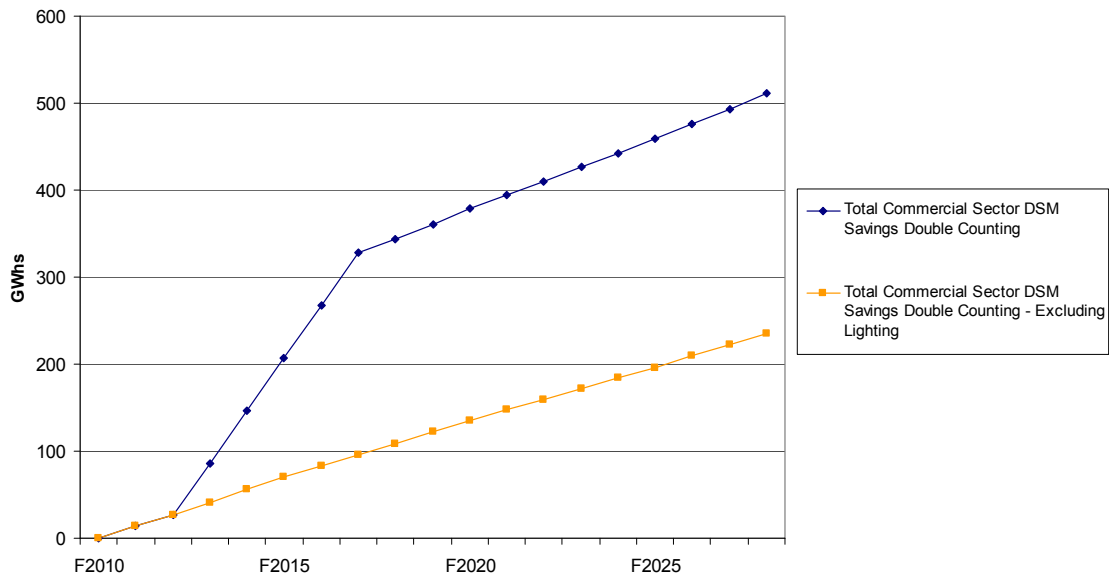
Table 3 – EIA and BC Hydro Baseline Codes and Standards for Building Shell and Lighting

End Use / Efficiency Area	EIA Assumption	BC Hydro Baseline Assumption	Comments
Building Shell Efficiency	ASHRAE 90.1 – 2007 phased in from 2011 through 2018	ASHRAE 90.1 – 1999	The building shell related codes and standards DSM energy savings are double counted as they are already captured in the EIA building shell efficiency levels.
Lighting	General Service Incandescent Lamps – EISA 2007 standard of maximum wattage limits for lumen ranges as per: Lumens/ Max Wattage 1490-2600/72 1050-1489/53 750-1049/43 310-749/29	General Service Incandescent Lamps – Average stock of current bulb wattages at current standards	EIA: General Service Incandescent Lamp Standard is addressed by EIA with new bulb wattage reduced by 28 percent in 2013 and by 67 percent in 2020. There is double counting of energy savings with the GS incandescent lamps.

As indicated, there is likely double counting of the codes and standards based energy savings for both of these efficiency items that amounts to approximately 400 GWhs in F2020.

Figure 21 provides an estimate of the energy savings double counting resulting from misalignment of codes and standards between the EIA and BC Hydro. These values are based on the BC Hydro code and standards energy savings plan for the commercial sector as per the 2008 LTAP Evidentiary Update.

Figure 21 – DSM Codes and Standards Energy Savings Considered to be in the Commercial Before Incremental DSM and Rate Impact Load Forecast



4.3.9 Efficiency Rebound

The EIA forecast assumes an efficiency rebound effect which is implicitly incorporated in the before DSM load forecast to represent an increase in load associated with improvements in efficiency over the forecast horizon in the before DSM load forecast. The DSM planning process incorporates an efficiency rebound impact associated with DSM driven efficiency improvements. Therefore, there is no structural double counting of efficiency rebound effects between the before DSM and rate impact load forecast and DSM programs.

4.4 Commercial Sector Issues and Recommendations

Table 4 outlines the main issues that have been identified in this review of the commercial distribution voltage sector along with alternate approaches to addressing these issues and a recommendation is provided. Many of the issues, alternatives and recommendations are the same as the residential sector.

Table 4 – Summary of Findings for the Commercial Distribution Sector

Load Forecast Component	Main Finding
Natural Conservation	
Issue(s)	Although natural conservation is recognized in both the DSM Plan and the Load Forecast, it is difficult to fully quantify the relative level of natural conservation included in each. Material inconsistencies in natural conservation assumptions could lead to the under or over counting of load.
Alternate Approaches	<u>Short Term</u> There are two short term alternatives to address the natural conservation issue: 1. Continue planning using current processes. 2. Continue planning using current processes and work toward improved sharing of planning assumptions between the DSM planning and load forecasting groups to support better alignment on natural conservation where possible. Continue to pursue additional clarity on marginal efficiency values from the EIA which will support quantifying natural conservation in the Load Forecast. <u>Long Term</u> The alternatives for the long term are: 1. Continue with the chosen short term solution. 2. Develop a common planning framework and stock turnover model for load forecasting and DSM planning to align natural conservation.
Recommendation	In the short term, recognize that both planning processes incorporate some natural conservation and work toward better integration on this issue. In the long term, develop a common planning framework and stock turnover model between load forecasting and DSM planning to align assumptions of natural conservation.
Natural Growth	

Load Forecast Component	Main Finding
Issue(s)	Load growth associated with existing and miscellaneous new end-uses appears to be reasonably well addressed within the Load Forecast. The DSM Plan also incorporates assumptions on natural growth. However, as with natural conservation, it is difficult to thoroughly quantify the relative amount of natural growth contained in each forecast.
Alternate Approaches	<u>Short Term</u> There are two short term alternatives to address the natural growth issue: 1. Continue planning using current processes. 2. Continue planning using current processes and work toward improved sharing of planning assumptions between the DSM planning and load forecasting groups to support better alignment on natural growth where possible. The alternatives for the long term are: <u>Long Term</u> 1. Continue with the chosen short term solution. 2. Develop a common planning framework and stock turnover model for load forecasting and DSM planning with consistent inputs.
Recommendation	In the short term, recognize that both planning processes acknowledge natural growth and work toward integration on this issue. In the long term, develop a common planning framework and stock turnover model to align assumptions of natural growth.
Basic Stock Turnover	
Issue(s)	It is reasonable to assume close general alignment between the Energy Information Administration (EIA) stock assumptions for the US pacific census region and those in British Columbia. This is why the EIA assumptions are used in BC Hydro's load forecasting process as a proxy for British Columbia stock turnover. However, there may be the potential for some differences in these assumptions due to the following: 3) Differences in fuel prices between US and British Columbia may result in the EIA Unit Energy Consumption (UEC) and Efficiency Factor (EF) values being more efficient in the US than in British Columbia. US electricity prices, which are higher than in BC, may drive more efficient electricity technologies than what may otherwise occur in British Columbia. 4) Stock turnover in the US pacific census region may be based on

Load Forecast Component	Main Finding
	regional consumer decision making variables that that are somewhat different than in British Columbia. Not all BC Hydro DSM planning processes are based on stock turnover modeling. However, where this occurs, the models are generally based on BC data - where possible. To this extent, it would be reasonable to assume general consistency in stock turnover modeling between BC Hydro DSM Planning and load forecasting processes given the above aspects of the EIA stock turnover model.
Alternate Approaches	<u>Short Term</u> In the short term, the only viable option is to continue using the EIA data for the before DSM and rate load forecasting process. <u>Long Term</u> There are three options to address stock turnover issues in the longer term. 4. Continue to use the EIA model as an input to the before DSM and rates load forecasting process; 5. Develop a BC Hydro stand-alone load forecasting stock turnover model for the before DSM and rates load forecasting process; and 6. Develop a common planning framework and integrated load forecasting and DSM forecasting stock turnover model that would provide the functionality of alternate 2 but also include the planning requirements for DSM. This would ensure unified data and assumptions between Load Forecasting and DSM planning.
Recommendation	There should be relatively close alignment between the US-based EIA and BC-specific stock options. However, to minimize the possibility of inconsistencies between basic stock turnover assumptions, alternative 3 is recommended.
Price Elasticity	
Issue(s)	The BC Hydro load forecast includes adjustments due to price elasticity effects. These arise from overall electricity rate level adjustments (Real \$), and are distinct from the effects from Conservation Rate Structures (see below). Therefore, there is alignment between Load Forecasting and DSM Planning in this area.
Alternate Approaches	No alternatives are required.
Recommendation	No actions required.

Load Forecast Component	Main Finding
Conservation Rate Structures	
Issue(s)	The DSM plan includes load adjustments due to the effects of conservation rate structures. These are distinct from the price elasticity effects that the Load Forecasting group includes in their load forecast. Therefore, there is alignment between load forecasting and DSM planning in this area.
Alternate Approaches	No alternatives are required.
Recommendation	No actions required.
Historic DSM	
Issue(s)	Regression-based load forecasting models can be susceptible to the effects of historic DSM savings, including the potential for double counting of DSM savings. However, the statistically adjusted end-use model that BC Hydro uses to prepare the residential load forecasts appropriately incorporates the effects of historical DSM appropriately, such that there is no concern of double counting.
Alternate Approaches	No alternatives are required.
Recommendation	No actions required at this time.
Incremental DSM Programs	
Issue(s)	Future DSM savings are forecast against baseline assumptions of expected future stock energy consumption and efficiency levels. If the EIA baseline assumptions used in the load forecast are substantially different from the DSM plan baseline assumptions, then there may be some double or under counting between the DSM plan and the load forecast.
Alternate Approaches	<u>Short Term</u> Where information is available and changes are practical, adjustments will be made to ensure load forecasting and DSM planning processes use consistent planning assumptions regarding baseline efficiency levels. <u>Long Term</u> Develop a common planning framework and stock turnover model that will be used for both DSM planning and load forecasting processes.

Load Forecast Component	Main Finding
Recommendation	Where information is available and changes are practical, adjustments will be made to ensure load forecasting and DSM planning processes use consistent planning assumptions regarding baseline efficiency levels. In the long term, develop a common planning framework and stock turnover model that will be used for both DSM planning and load forecasting processes.
Codes and Standards	
Issue(s)	Future DSM savings attributable to new codes & standards are forecast against baseline assumptions of expected future stock energy consumption and efficiency levels. If the EIA baseline assumptions used in the load forecast are substantially different from the DSM plan baseline assumptions, then there may be some double or under counting between the DSM plan and the Load Forecast. Double counting of DSM energy savings in the commercial sector Load Forecast for some end uses has been positively identified. This is because codes & standards efficiency gains attributed as DSM savings are already included in the EIA assumptions that are used to prepare BC Hydro's commercial sales forecasts. Based on the analysis undertaken by BC Hydro, the double counting amounts to approximately 400 GWh in F2020 for the commercial sector.
Alternate Approaches	<u>Short and Long Term</u> If the EIA data is to be used on an ongoing basis, the baseline assumptions of codes and standards between EIA and DSM planning should be monitored on an ongoing basis. In the short term, any double counted energy saving should be addressed in the before incremental DSM load forecast, provided these savings continue to be included in the DSM Plan. In the long term, the development of a common planning framework and stock turnover model would address this issue.
Recommendation	In the short term, make the necessary adjustments to the Load Forecast to account for the codes and standards double counting. Ongoing effort will be required to ensure alignment between the EIA and DSM Plan codes and standards efficiency level assumptions in future versions of the BC Hydro Load Forecast. In the longer term pursue the development of a common planning framework and stock turnover model that would be used for load

Load Forecast Component	Main Finding
	forecasting and codes and standards planning, incorporating consistent planning assumptions.
Efficiency Rebound Effect	
Issue(s)	There is structural alignment of efficiency rebound effects between the load forecast and the DSM plan.
Alternate Approaches	No alternatives required.
Recommendation	No actions required.

4.7 Commercial Transmission Sector

BC Hydro uses the same forecasting techniques for the commercial transmission sector and the industrial transmission sector. Therefore, the transmission sector DSM and load forecasting integration issues are addressed in one section within Section 5.0 of this report.

5.0 Industrial Sector

Approximately 20 percent of the industrial sector load is composed of customers that are served at the distribution voltage and approximately 80 per cent of the industrial sector load is composed of customers that are served at the transmission voltage. This section addresses each of these load sub-sectors separately as they use different forecasting methodologies.

The 2009 industrial distribution voltage before incremental DSM and rate impact load forecast is prepared primarily using a traditional regression model. The industrial transmission voltage before incremental DSM and rate impact load forecast is prepared by individual account. Due to different forecasting techniques, the subset of integration issues is smaller in the industrial sector than in the residential or commercial distribution voltage sector.

5.1 BC Hydro Industrial DSM Plan

The DSM Plan targets demand side load reductions through DSM programs, rate structures and codes and standards.

Industrial DSM Programs – These are 4 industrial DSM programs that include the following:

1. Power Smart Partner - Transmission
2. Power Smart Partner – Distribution
3. New Plant Design
4. Load Displacement

Rate Structures – A two-step, inclining block rate is in place for transmission voltage customers and a two-part rate structure is in place for industrial distribution voltage customers in the large general service class.

Codes and Standards – More efficient codes and standards are included in the DSM Plan that target the industrial sector in the areas of large motors, transformers, luminaires and street lights.

5.2 Industrial Distribution Sector Key Issues

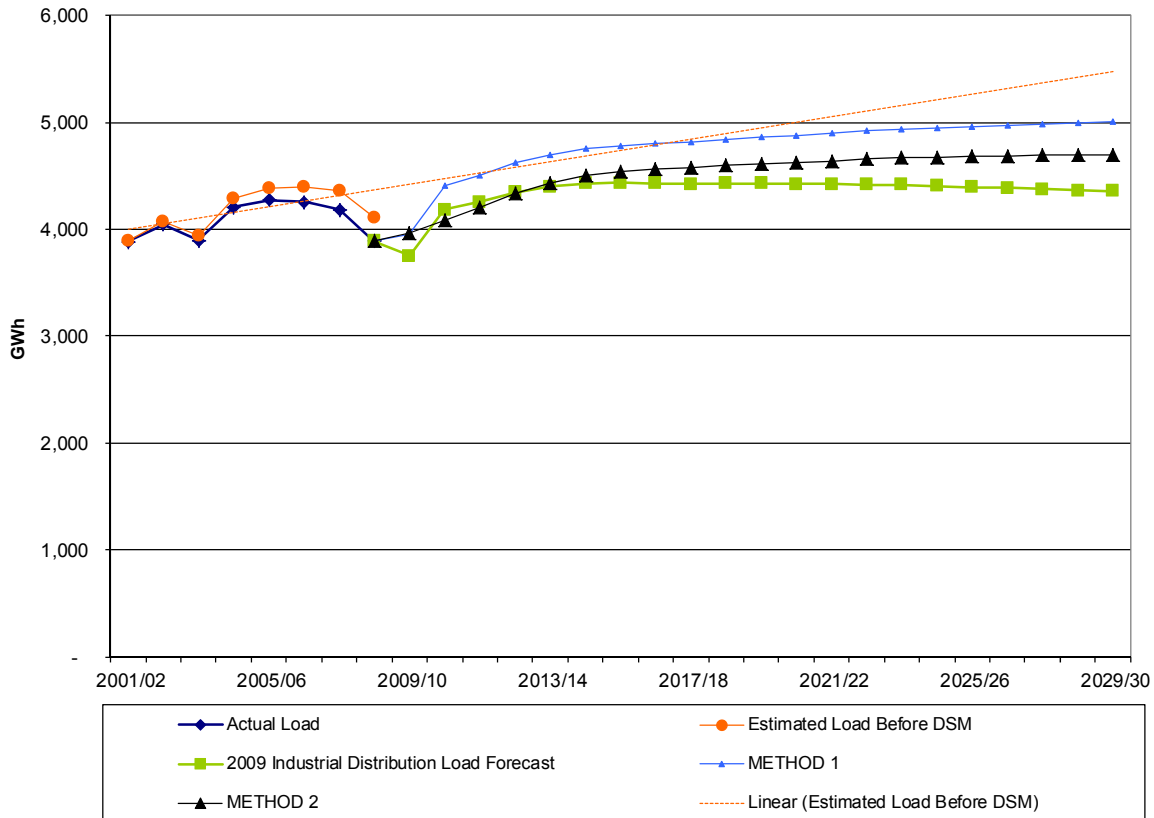
The main area examined in this report for the industrial distribution sector is the potential impact of historic DSM in the industrial distribution voltage load.

The scope of the review did not include examining natural conservation or natural growth for the industrial distribution voltage sector given expected difficulties in explicitly identifying these elements of the industrial distribution load forecast, as a result of the method of forecasting applied to this sector. However, these areas should be examined further in subsequent efforts involving alignment of Load Forecasting and DSM planning.

5.2.1 Historic DSM Impact

The industrial distribution sector before incremental DSM and rate impact load forecast is prepared using a regression model. The industrial distribution forecast equations are determined with historical GDP, a trend line and actual industrial distribution load values and therefore incorporate the historic impacts of DSM. Methods 1 and 2, as described in the residential section of this report were applied to the industrial distribution voltage load forecasting process. The results are shown in Figure 22 and are discussed below.

Figure 22 – Methods 1 and 2 Industrial Load Forecast



The forecast that is developed using method 1 has lower explanatory power than the 2009 load forecast making this an inferior forecasting model than the current model.

When method 2 is used to prepare the industrial distribution voltage load forecast, the model has the same level of explanatory power as the current model. However, the DSM variable that is added to the regression equation is not statistically significant.

For the above reasons, both methods 1 and 2 are rejected as improvements to the current methodology to prepare the industrial distribution before incremental DSM and rate impact load forecast.

5.3 Industrial Transmission Sector Key Issues

This section addresses the industrial transmission voltage customer issues. The methodology used to prepare the commercial transmission voltage load forecast uses the same methodology as with the industrial transmission voltage load forecast, and therefore, this section also addresses commercial transmission voltage load forecasting.

Based on an initial review of the DSM and load forecasting integration issues, the main areas of concern for the transmission voltage customers are DSM programs, natural conservation and the potential impact of historical DSM.

5.3.1 DSM Programs

The before incremental DSM and rate impact load forecast associated with existing production capacity for each transmission voltage account is prepared taking into consideration the historic intensity of energy consumption for the account. Therefore, the load forecast takes into account the impacts of historic DSM.

The forecast load associated with future expansions of production for each account is informed by estimates provided by the customer. There is the potential for the estimate provided by the customer to include some expected DSM impacts which are also captured in the industrial DSM program planning process. However, this potential will vary on an account-by-account basis.

Similarly, new customer loads may be subject to DSM double-counting. The intensity of electricity consumption for new customers may include the effects of DSM programs that were implemented in order that the customer would initially install more energy-efficient equipment. If both Load Forecasting and DSM planning were to include these savings in their respective forecasts, the result would be a double-counting of savings.

Based on the above, there is the potential for some overlap of DSM program savings between DSM and load forecasting for new customers and expansion projects within the transmission voltage accounts. Close coordination between DSM planning and Load Forecasting is required in order to minimize the potential for double counting of DSM in this sector.

5.3.2 Natural Conservation

The DSM Plan for the industrial transmission sector incorporates natural conservation. However, the before incremental DSM load forecast for this sector does not incorporate natural conservation beyond historic intensity levels. There is misalignment in this area between Load Forecasting and DSM planning. The options to deal with this potential misalignment are to remove natural conservation from the DSM plan for this sector, or to incorporate natural conservation in the before DSM Load Forecast for this sector. The later approach is the most appropriate.

5.3.3 Historic DSM Impact

The load forecast for each transmission voltage account incorporates the historic energy usage intensity of each account and therefore incorporates the impact of historic DSM.

Given that a bottom-up account by account load forecasting methodology is utilized for transmission voltage customers, if there is close coordination between the Load Forecasting and DSM planning groups with respect to the appropriate accounting of new program savings, then the level of potential DSM double-counting is minimized.

5.4 *Recommendations for the Industrial Sector*

For the industrial distribution sector, it is recommended that additional efforts be undertaken to examine the area of natural conservation.

For the industrial transmission sector, it is recommended that the Load Forecasting and DSM planning staff who prepare the industrial and commercial transmission voltage forecasts continue to meet annually to review planning assumptions and work to incorporate consistent assumptions in the respective forecasts.

Appendix I – SAE Model Description

BC Hydro forecasts the residential and commercial distribution sales⁶ by using the Statistically Adjusted End-Use model (SAE). This model incorporates end-use information, economic data, weather data and market data to construct regional forecasts.

The SAE model defines energy use in year and month (m) as the sum of energy used by heating equipment ($Heat_m$), cooling equipment ($Cool_m$), and other equipment ($Other_m$). Formally,

$$USE_m = Heat_m + Cool_m + Other_m$$

This equation can be shown in a regression form, as:

$$USE_m = a + b_1 \times XHeat_m + b_2 \times XCool_m + b_3 \times XOther_m + \varepsilon_m$$

Here, $XHeat_m$, $XCool_m$, and $XOther_m$ are explanatory variables constructed from end-use information, economic drivers, dwelling data and weather data and ε_m is the error term for the regression. The estimated model can then be thought of as a statistically adjusted end-use model, where the estimated coefficients are the adjustment factors or the relative contribution by the major end uses to the total consumption.

The equations used to construct these X-variables are simplified end-use models, and the X-variables are the estimated usage levels for each of the major end uses.

The statistically adjusted end-use modeling framework begins by defining energy use (Use_m) in year and month (m) as the sum of energy used by heating equipment ($Heat_m$), cooling equipment ($Cool_m$), and other equipment ($Other_m$). Formally,

$$(A1) \quad USE_m = Heat_m + Cool_m + Other_m$$

Equation (A1) can be shown in a regression form, as shown below in (A2):

$$(A2) \quad USE_m = a + b_1 \times XHeat_m + b_2 \times XCool_m + b_3 \times XOther_m + \varepsilon_m$$

Here, $XHeat_m$, $XCool_m$, and $XOther_m$ are explanatory variables constructed from end-use information, economic drivers, dwelling data and weather data and ε_m is the error term for the regression. The estimated model can then be thought of as a statistically adjusted end-use model, where the estimated coefficients are the adjustment factors or the relative contribution by the major end uses to the total consumption.

⁶ The commercial sales are composed of commercial general rate class, transmission and BC Hydro Own Use, Irrigation, Street-lighting. The SAE model is used to forecast the sales for the commercial general rate class. The sales forecast for BC Hydro Own Use, Irrigation, and Street-lighting is done using historical sales data and trend analysis.

The equations used to construct these X-variables are simplified end-use models, and the X-variables are the estimated usage levels for each of the major end uses based on the end use models.

Constructing XHeat. Space heating energy is specified to depend on the following types of variables:

Heating degree days (weather),

Heating equipment saturation levels (fraction of building stock for the commercial sector),

Assumptions about heating equipment operating efficiencies,

Average number of days in the billing cycle for each month,

Economic variables include employment, retail sales and commercial output.

The heating variable is represented as the product of an annual equipment index and a monthly usage multiplier. That is,

$$(A3) \quad XHeat_m = HeatIndex_m \times HeatUse_m$$

where, $XHeat_m$ is estimated heating energy use in a year (y) and month (m), $HeatIndex_y$ is the annual index of heating equipment in the year (y), and $HeatUse_m$ is the monthly usage multiplier.

The sub equation for $HeatIndex_m$ in (A3) is:

$$HeatIndex_y = \sum_{spaceheating} EndUseEnergy_{e,BaseYear} \times \frac{\left(\frac{Share_y}{Eff_y} \right)}{\left(\frac{Share_{BaseYear}}{Eff_{BaseYear}} \right)}$$

Where, y means year, e refers to the category of space heating, Share means saturation level of space heating, Eff means efficiency level of space heating based on Energy Information Administration (EIA) data, and Base Year means the year of the BC Hydro end use survey.

The sub equation for $XHeatUse_m$ in (A3) is:

$$HeatUse_m = Commercial\ GDPIndex^{\beta^1}_m \times EmploymentIndex^{\beta^2}_m \times RetailSalesIndex^{\beta^3}_m \times Heating\ Degree\ Days\ Index_m$$

Where m refers to month specific values and the β values are the elasticities that apply to the various regional economic indices above (i.e., commercial GDP, employment, and retail sales) and small commercial sales. The economic indices for each variable are developed based on a 12 month rolling average of the economic variable weighted by its average monthly value in the last historical year.

The heating equipment index (HeatIndex) depends on the space heating equipment saturation levels normalized by average operating efficiency levels. As a result, the index will increase over time if there are increases in heating equipment saturation levels, and will decrease over time if there are improvements in equipment and building efficiency levels. Heating system usage levels (HeatUse) are driven on a monthly basis by economic variables and non-economic factors, such as weather (Heating Degree Days).

Constructing XCool. The explanatory variable for cooling loads is constructed in a similar manner. The amount of energy used by cooling systems depends on the following types of variables:

Cooling degree days (weather),

Cooling equipment saturation levels (fraction of building stock for the commercial sector),

Assumptions about cooling equipment operating efficiencies,

Average number of days in the billing cycle for each month,

Economic variables include employment, retail sales and commercial output.

The cooling variable is represented as the product of an equipment-based index and monthly usage multiplier. That is,

$$(A4) \quad XCool_m = CoolIndex_m \times CoolUse_m$$

where, $XCool_m$ is estimated cooling energy use in a year and month (m),

$CoolIndex_y$ is an index of cooling equipment for the year (y), and

$CoolUse_m$ is the monthly usage multiplier.

As with space heating, the cooling equipment index (CoolIndex) depends on the cooling equipment saturation levels normalized by average operating efficiency levels. As a result, the cooling index will increase over time if there are changes in cooling equipment saturation levels, and will decrease over time if there are improvements in equipment efficiencies or the thermal efficiency of buildings. Space cooling system usage levels (CoolUse) are driven on a monthly basis by several factors, including weather (Cooling Degree Days) and similar economic factors used to develop heating usage.

Constructing XOther. Monthly estimates of consumption for non-weather sensitive end uses can be derived in a similar fashion. Non-weather sensitive end-uses include lighting, refrigeration, cooking, clothes washing and drying, entertainment and other miscellaneous equipment. Based on end-use concepts, other sales are driven by:

Appliance and equipment saturation levels,

Appliance efficiency levels,

Average number of days in the billing cycle for each month, and

Economic factors

The explanatory variable for other uses is defined as follows:

$$(A1.10) \ XOther_m = OtherEqIndex_m \times OtherUse_m$$

The first term on the right hand side of this expression ($OtherEqIndex_y$) embodies information about appliance saturation and efficiency levels. The second term ($OtherUse$) captures the impact of changes in economic variables that impact use of other equipment. These economic variables are similar to those used for explaining heating and cooling.